PROJECT PLAN

(RISK MANAGEMENT PLAN included)

Checkout and Launch Control System (CLCS)

84K00051

Agreements:

______________________________ ____________
Project Manager, CLCS Date

______________________________ ____________
Director of Shuttle Processing Date

______________________________ ____________
Chairman, CLCS PMC (CD, KSC) Date

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PROJECT PLAN

CHECKOUT AND LAUNCH CONTROL SYSTEM (CLCS)

1.0 INTRODUCTION

1.1 IDENTIFICATION

The Checkout and Launch Control System (CLCS - UPN 26070, Shuttle Launch Site Equipment Upgrades) will replace the current Launch Processing System (LPS) with state-of-the-art technology. The 60 Day Pilot Project was referred to as New/National LPS (NLPS). CLCS became the official name for the project in November 96.

1.2 BACKGROUND

The existing Launch Processing System (LPS) supporting the Shuttle Program is 1970's technology. It suffers from reliability and obsolescence problems and has serious expansion limitations. An LPS Upgrade Review Team was formed in April 96 which resulted in a recommendation to provide a new LPS where the strategies emphasized were to 1) leverage technology and products, 2) replace GOAL, and 3) employ rapid development (build a little, test a little).

A Level III CCBD issued in mid June 96 authorized a 60 Day Pilot Project dubbed New LPS (CLCS) . The 60 day analysis produced a *Management and Technical Volume* and a *Cost Volume* which together define the Project Baseline.

In October 96, the project received start-up funding, enabling the team to officially initiate the project, beginning with *JUNO*, the project's first delivery. In November 96, the project officially became known as CLCS. A Change Request (CR) was approved in December 96 to provide funding for the entire five year effort.

1.3 SUMMARY

The replacement of LPS with CLCS will resolve the current reliability and obsolescence problems and will provide a platform to preclude future obsolescence issues. The CLCS concept also moves away from processes invented based on 1970s technology and takes full advantage of modern Commercial Off the Shelf Equipment. This improved system reliability, flexibility, and supportability will significantly reduce O&M costs. By keeping pace with today's technology, improvements in Shuttle data availability and distribution will be achieved.

CLCS system represents NASA's investment in the future which will ensure continued safe and dependable Shuttle Launch Support for the duration of the program, reduce Shuttle operational costs, and provide building blocks for future endeavors.

CLCS has an aggressive, success driven, product oriented, five-year schedule with deliveries to the end user every six months. Each incremental delivery provides an additional system capability that is built on top of the previously delivered capabilities. Best products from industry and government agencies will be combined to provide a showcase CLCS at the Kennedy Space Center.

2.0 PROJECT OBJECTIVES

Although Kennedy Space Center is already designated as NASA's lead Center of Excellence for Launch and Cargo Processing Systems, continuing business as normal is not acceptable in an age when resources are scarce. In parallel with the *NASA Strategic Management Handbook* to do things better and for less cost, CLCS is more than a replacement of 20+ year old hardware to reduce O & M costs and obsolescence problems. The primary goal of the CLCS project is to redefine the Space Shuttle processing environment to improve checkout efficiencies. The CLCS Project will require complete review of the functional requirements of hardware, system software and end user application software. This includes a thorough examination of our culture and the way in which we are accustomed to processing vehicles and payloads. The preliminary analysis phase has already identified several key areas where operational efficiencies can be achieved, changes to today's process that cannot be readily implemented due to the limitations of the existing hardware. As the Shuttle Program embraces "change for efficiency", CLCS will provide an adaptable platform to implement critical and necessary process enhancements, as well as provide the ability to support Shuttle upgrades and future advanced launch systems.

As the *NASA Strategic Management Handbook* also stresses the communication, sharing, and transfer of information, CLCS merges the multiple data sources in existence today into one central data resource which can easily be distributed to other NASA centers and beyond. This capability will support the fulfillment of NASA's goal to enhance the Space Operations Services to its customers during the mission preparation and launch phases.

The CLCS Project follows many of the "Critical Success Factors" as defined in *The Strategic Plan* for *NASA's Enterprise for the Human Exploration and Development of Space.* These include:

- Decreasing Space Shuttle costs and improving the management and operations of the integrated government/contractor team;
- Achieving dramatic reductions in the cost of space flight;
- Maintaining a skilled and motivated workforce;
- Maintaining high ethical practices and respecting the human and civil rights of our workforce and our partners.

3.0 MANAGEMENT

3.1 ORGANIZATION AND RESPONSIBILITIES

CLCS is a NASA-managed re-engineering activity, funded by and operated under the auspices of the Space Shuttle Program (see section 4.0). Contractor support is provided under existing NASA contracts: the Space Flight Operations Contract (SFOC), the Mission Support Contract (MSC), the Engineering Support Contract (ESC), the Base Operations Contract (BOC), and the Payload Ground Operations Contract (PGOC). Figure 3.1-1 illustrates the CLCS organization structure.

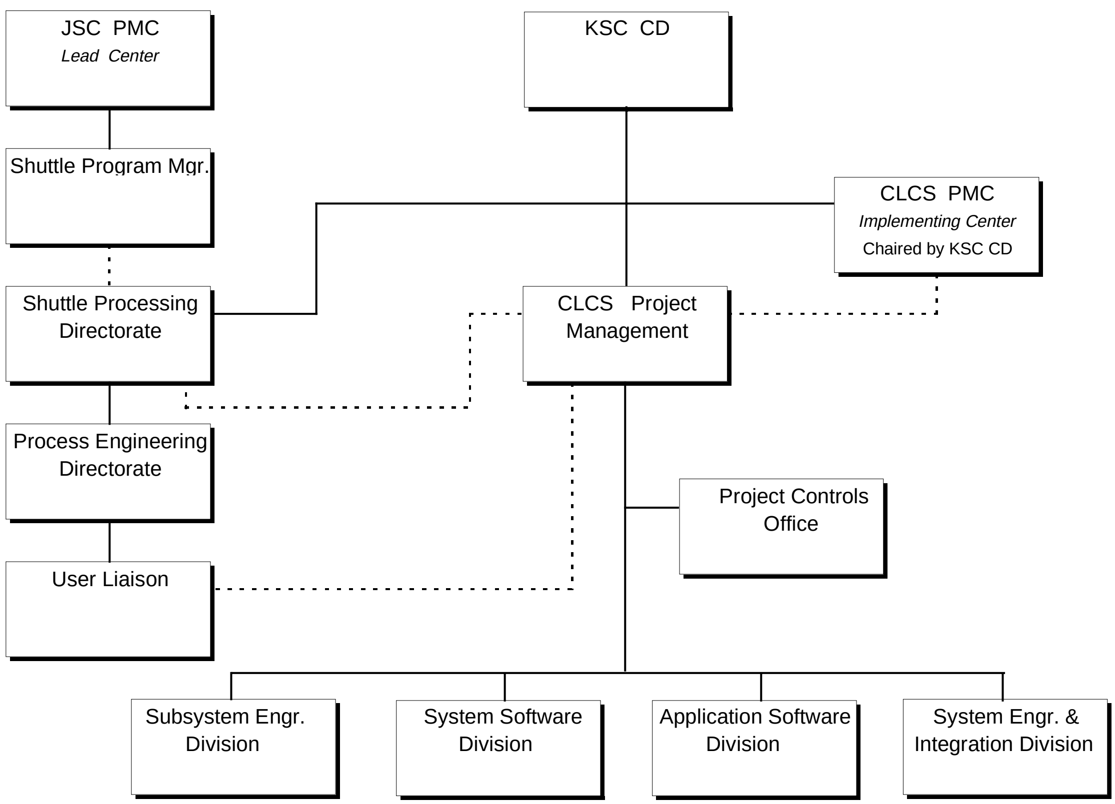

Figure 3.1-1 Organization Structure

3.1.1 CLCS PROJECT MANAGEMENT COUNCIL (PMC)

The CLCS PMC consists of several members of KSC and JSC upper management who represent many dedicated years of experience in guiding and directing NASA in the achievement of its goals and mission. This organizational element will provide expertise and sound judgment on high level CLCS issues and will monitor the overall progress of the project relative to budget and schedule. They will also provide guidance, as required, so as to assure that CLCS fulfills the overall NASA mission. The CLCS PMC is chaired by KSC's Center Director. Other members are as follows: Deputy Director, KSC, Associate Director, Shuttle Upgrades (KSC), Chief Information Officer (KSC), Director of Shuttle Processing (KSC), Director of Engineering Development (KSC), Director of Logistics Operations (KSC), Director of Safety and Mission Assurance (KSC), Director of Payloads Processing (KSC), Director of Installation Operations (KSC), Chief Financial Officer (KSC), Director of Space Operations (JSC), and Project Manager, Checkout and Launch Control System Office (KSC).

3.1.2 Project Management

The NASA Project Manager and Deputy Project Manager are responsible for the overall management of the CLCS Project and have accepted the responsibility to ensure that the CLCS Project is implemented in the most expeditious and cost-effective manner. They have the authority to approve principal project documents, contract and performance reports, control room transition strategy and priority, and content for upper level status briefings.

3.1.3 Project Controls Office

Project Controls will work with System Engineering and Technical Integration to provide direct support to the NASA Project Managers. The Project Controls organizational element is responsible for project level plans, processes, and schedules, budget actions, IT and Buy Plans, procurements, contract management, facility readiness, network administration, personnel training, production configuration management, non-technical integration, project and contractor performance measurement/reporting.

3.1.4 System Engineering and Integration Division

System Engineering and Integration will work with Project Controls to provide direct support to the NASA Project Managers. The System Engineering and Integration organizational element is responsible for project level strategic planning and coordination, system level hardware, software, platform, and network architecture planning, development, and implementation, system level requirements capture, reliability and maintainability analysis and engineering, logistics engineering support planning, coordination, and integration, security engineering, pre-production configuration management, integration and test certification plans, and the coordination of technology studies and synergy.

3.1.5 User Liaison

User Liaison will represent the User Community to assure that CLCS will meet the necessary requirements to fulfill KSC processing and launch mission. This organizational element will remain part of the Shuttle Operations Directorate and is responsible for: definition and collection of User’s Functional Requirements (includes Shuttle, Ground Support Equipment (GSE), Complex Control System (CCS), and Payloads), defining and performing user test plans, evaluating, certifying, and validating CLCS hardware and software products, identifying transition users’ requirements and operational impacts, defining Human Computer Interfaces, ensuring accurate implementation of application software design requirements, integrating users inputs into delivery and facility schedules, identifying impacts to OMI ‘s and other documentation, and identifying and coordinating users’ training requirements. A user-based screening and prioritization function may be required to balance the highest priority user ideas versus available resources and schedule.

3.1.6 Subsystem Engineering Division

Subsystem Engineering is a development organizational element responsible the design, development, testing, and delivery of CLCS gateways, consoles, platforms, safing subsystem, networks and other interfaces. Subsystem Engineering will support Project Controls by providing schedule, budget, training, and procurement inputs as required. Subsystem Engineering will work closely with System Engineering and Integration providing input to system architecture and delivery planning and coordination as required.

3.1.7 System Software Division

System Software is a development organizational element responsible for the design, development, testing, and delivery of system software services that allow CLCS to operate. These services provide the mechanism for user applications, unique system programs and software development tools to run on CLCS. System Software will support Project Controls by providing schedule, budget, training, and procurement inputs as required. System Software will work closely with System Engineering and Integration to provide input to system architecture and delivery planning and coordination as required. System Software will work with Application Software to control the software development tools and environment.

3.1.8 Application Software Division

Application Software is development organizational element responsible for the design, development, testing, and delivery of CLCS user application software. This includes establishing standards, guidelines, policies and procedures for programming, documenting, reusing, and developing application software with appropriate Control Boards, and Life-Cycle Methodology. Application Software will support Project Controls by providing schedule, budget, training, and procurement inputs as required. Application Software will work closely with System Engineering and Integration providing input to system architecture and delivery planning and coordination as required. Application Software will work with System Software to control the software development tools and environment.

Application Software is also responsible for the design, development, testing, and delivery of simulation services. These services provide the mechanism for the creating, maintaining, testing, and executing of math models and model control language and provide the common functions needed by CLCS to test and checkout hardware/software functionality.

3.2 SPECIAL BOARDS AND COMMITTEES

CLCS Project Management Council (PMC) (reference section 3.1.1)
Shuttle Operation Management Organization (SOMO) (reference section 4.3)

3.3 MANAGEMENT SUPPORT SYSTEMS

As with any project, monitoring and measuring cost and schedule performance of the project is essential to its overall success. The CLCS project will maintain three schedules; 5-Year Master Delivery Schedule, 5-Year Project Schedule, and a detailed integrated schedule for each of the 10 incremental deliveries. The integrated schedule is a composite or roll-up of low-level schedules for each of the many products and threads which make up the delivery. As a minimum, data and status will be collected and internally reviewed at the project's weekly "stand-up" session. The "stand-up" session will specifically identify areas of concern as well as successes of the previous week.

Monthly reports are prepared by each of the project's contractors. These reports indicate the full-time-equivalents charged to the project the previous month and other related costs. In coincidence with the receipt of these reports, this data, along with procurements of non-labor items are analyzed against the project's cost plan.

The Micro Soft Office package will be used to support this effort including MS Project, CLCS's scheduling tool. CLCS takes advantage of networks and web processes and technologies to distribute project information and data.

CLCS is developing the CLCS Performance Measurement Plan (PMP) which will be used to assess cost, schedule, and technical performance beginning with the second delivery. It is intended that this and other performance measurement tools used by the CLCS project will enable project management to prepare a brief but accurate report as an insight to the overall performance of the project.

Perhaps one of the most important tools to CLCS's project management is the project's approach of incremental deliveries, i.e. ten small deliveries, one every six months. This approach ensures that the system is delivered, not paper/theory on what the system "should be". These six month drops are integral to the success and risk mitigation of the project. Having in-depth involvement from the user community as another key element to the project's success allows for early detection of latent flaws, quick turnaround of system fixes, and provides early user review of the real system (not paper design).

4.0 RELATIONS TO OTHER ELEMENTS

4.1 SHUTTLE PROGRAM

The CLCS Project is funded by and operates under the auspices of the Space Shuttle Program (SSP). The SSP Manager, representing the Lead Center PMC, receives information and status on the CLCS Project on a periodic basis (quarterly or as requested by Program Manager) reflecting the technical and cost progress of the project. It is intended that the reporting of CLCS status and issues will be weaved into existing programmatic processes. The SSP Manager also approves Change Requests (CRs) for the project where new requirements have the potential to impact budget or schedule.

Funding for CLCS is carried as a Launch Support Equipment (LSE) line item under the responsibility of KSC's Director of Shuttle Processing.

4.2 SPACE STATION

No requirements for CLCS to support or interface with Space Station are defined at this time.

4.3 SHUTTLE OPERATION MANAGEMENT ORGANIZATION (SOMO)

The high-level architecture and functionality proposed for CLCS is similar to those architectures that exist or are being developed at other NASA and DOD Centers. In keeping with the charter for which SOMO was organized, to promote synergy and commonality across the development and operations of the different NASA Centers (thus reducing overall project costs), the CLCS Project envisions utilizing SOMO as a resource for information on CLCS-like Projects at those other Centers. In addition, CLCS Management and Engineering personnel will provide CLCS design and implementation information to the SOMO organization for retention in the SOMO Information Database and for analysis for commonality within the Agency.

In order to accomplish these technical communications, the CLCS Project will appoint a SOMO Liaison from the Project to interface with the designated SOMO representative(s) on a periodic basis. In addition, the designated SOMO representative(s) will be advised of and invited to the various Project Planning and Design Reviews where overall system Ops Concepts and architectural designs will be presented.

Based on SOMO recommendations, CLCS Project personnel would support attendance at other NASA Center design reviews to assist in the “search for synergy” across the other agency projects.

4.4 NON-ADVOCACY REVIEW (NAR)

CLCS will support the NAR team in it’s independent assessment of the CLCS project and will incorporate/implement findings, issues, and concerns as directed.

4.5 COEXISTENCE WITH LPS SURVIVABILITY

The LPS Survivability Project will coexist with the CLCS but will not be in competition for resources. The purpose of the Survivability Project is to insure that the existing control rooms are capable of supporting the manifest while the CLCS is being developed.

The Project Management of CLCS will provide management and technical guidance into the LPS Survivability Project. This guidance will include providing authority to proceed for all LPS Survivability Design, Development, Procurement, and Deployment Phases. The CLCS Project manager will approve the LPS Survivability Project budget and schedule.

5.0 TECHNICAL SUMMARY

The need for an automated launch processing system at KSC evolved from the Shuttle Transportation System (STS) requirements that included the need for rapid launch turnaround to meet the projected launch rate and program economic objectives. In June 1972, after analysis of Shuttle processing requirements, the LPS concept, which led to the present Launch Processing System (LPS) configuration, was baselined. Design of LPS was completed in 1976 followed by Firing Room integration and applications software development.

KSC has successfully used LPS since the early 1980s for the Shuttle operations. However, the system lacks modern computing capabilities, uses an archaic custom programming language, and requires numerous patch-in, subsystem add-ons to maintain its capabilities with changing mission requirements.

5.1 REQUIREMENTS

CLCS is required to replace the functionality of the existing Launch Processing System which is an integrated network of computers, data links, displays, controls, hardware interface devices, and computer software required to control and monitor flight systems, ground support equipment (GSE), and facilities used in direct support of Shuttle vehicle activities. Although O&M of the Hardware Interface Modules (HIMs) will eventually fall under the O&M tasks of CLCS, the replacement of the HIMs is not part of the CLCS effort as they are currently being replaced as a separate effort.

CLCS is required to replace the functionality of LPS sets currently located in:

1) Firing Room One	2) Firing Room Two
3) Control Room Three	4) Control Room Four
5) Complex Control Set	6) Hypergolic Maint. Facility
7) Cargo Integrated Test Equipment	8) Shuttle Avionics Integration Laboratory
9) Dryden Flight Research Center	10) Processing Control Center

Although CLCS is replacing an existing system where requirements are well defined, the CLCS team will work diligently to challenge and separate real requirements from 20 years of cultural influences, thus minimizing the complexity of design, ensuring that COTS products can be implemented into the CLCS design, and allowing for greater flexibility and creativity in the fulfillment of the “real requirements”.

Involvement of the user community is critical to the success of the CLCS project and therefore this involvement will be part of each phase of each incremental delivery. The user community is responsible for developing, approving, and performing the test plans for the verification, validation, and certification of CLCS. Contributions from software test and integration professionals and the perspective of risk management experts (Launch Director, Director of Shuttle Processing, Director of Safety and Mission Assurance, etc.) will also be included.

CLCS will also redefine the Space Shuttle processing environment in several key areas which will improve checkout efficiencies:

- Command and monitor data paths will be separated
- Monitor data will be distributed freely without fear of inadvertent command issuance
- Launch team members will be able to view test, playback, or simulated data in their office environment
- Test engineers will be able to monitor and control multiple systems from a single console
- Each Operations Control Room (OCR) will be capable of being divided into multiple 'Flow Zones' as needs dictate; each linked to a different Orbiter under test
- Multiple Orbiters located in any facility (OPF, VAB, Pad) will be capable of being controlled from a single OCR
- Only three control rooms will be required (one existing control room will be eliminated as CLCS is deployed)
- Consolidation of data:
  - Data currently residing across multiple platforms (CCMS, RPS, CDS) will be integrated into the Shuttle Data Center (SDC)
  - Common interfaces to a variety of data sources, such as acoustic data, hazardous gas detection data, etc. will be provided to the test engineer at his console
- Integration of complex/facility control
  - Control of facility systems will be moved into the vehicle control rooms
  - The Complex Control Set (CCS) will be eliminated
- Implementation of Local Commanding Operations
  - The system will allow commanding from specific controlled areas outside the OCRs as enabled by Test Conductors
  - Subsystem re-test will be able to be performed locally at the test end item with minimal control room support
- Program compatible data
  - CLCS uses data formats and protocols compatible with other NASA Centers
  - Manned Spaceflight Centers can share data and more easily compare information
- Support future vehicles
  - CLCS uses a flexible architecture that can easily and economically be adapted to support other/future vehicles
  - The use of COTS equipment and software ensure that CLCS will be a cost effective solution to future economical vehicle processing

5.2 SYSTEMS OVERVIEW

There are several underlying principles that have shaped the architectural definition of CLCS. Together, these principles will improve the operational benefits of CLCS while decreasing the long term cost to the Shuttle Program.

Leveraged Solution: Reduce the cost of CLCS implementation by leveraging off other existing work. This includes applicable work from KSC and other NASA centers; COTS hardware, operating systems, languages and tools; and standards ranging from ISO to ANSI to ad hoc. This represents a savings in both development and maintenance costs.

Scaleable Distributed Architecture: CLCS is based on a distributed architecture that can be scaled by increasing the capacity on a box by box level rather than having to replace the entire system. Maximum data rates across the system were determined. Each box will be sized to handle this maximum load in order to ensure adequate performance during peak demands.

Message Based Rather Than Storage Based: Reliable messages, rather than a common system wide data store, have been chosen as the glue that binds the system together. Reliable messaging is a well understood approach for building distributed systems and is available as a COTS solution via multiple technologies. It simplifies redundancy management within CLCS sets and increases the fidelity and quality of End Item monitoring and control.

Improved Fault Tolerance: Fault tolerance and redundancy management is extended to cover End Item user applications. It is these applications that provide safe and effective control of the Space Shuttle and GSE. As a minimum fail-safe operation will be supported. Additional fail-operational support will be provided where practical.

Consolidated Data: In addition to the present data links supported by LPS today, CLCS will consolidate data from a number of other links that provide End Item test relevant information. This will enhance the information available to control room operational personnel to aid in making informed decisions.

Reliable Data: CLCS provides substantial improvement in the delivery of reliable End Item data to users and user applications. The improvements are data health, reliable data delivery, and complete data delivery***.*** ***Data health*** information is provided for each Function Designator (FD) or measurement update allowing it to be tested for usability directly. Data health factors in Gateway status for the FD, knowledge of the FD's data path's health, and input from engineering. ***Reliable data delivery*** ensures that each concentrated FD update message is received resulting in no missing blocks of FD updates. FD update messages occur at a fixed periodic rate to each subscribing computer and are numbered. If a subscribing computer misses a message, retransmission can be requested. ***Complete data delivery*** ensures that an application can process all data changes for selected FD's, not just the values that existed when an application reads them. FD updates, including time of change and health, will be queued for the application and can be processed as required by the user application.

Transforming Data into Information: The individual measurement FD's from each End Item LRU provide data about the LRU but not usually any directly usable information. ***Data fusion*** combines values of multiple FD's with good data health to determine state of an LRU or other summary information to form a new FD that can be tested directly. As an example, data fusion FD can be use for the OPEN/CLOSED state of a valve or the ON/OFF state of Orbiter power. Use of data fusion FD's greatly simplifies user application development and data retrieval.

Increased Availability: Numerous features within CLCS extend the availability and level of service. Additional control room personnel such as test directors, and remote personnel such as engineering in test/work areas can join into CLCS testing through built in access safeguards using dedicated and portable workstations. The logging of consolidated data makes test information more available to all CLCS users.

Layered Applications: Applications software in CLCS is provided by a minimal number of focused layered tools. This reduces the amount of application program development required and makes them more understandable. Layering allows actions to be defined and tested once and used repeatedly. As an example data health and data fusion permits the logic of coming up with the state of an LRU to be defined once. It can be reused with confidence by many application programs, user displays, and data retrievals for years to come.

Improved End Item Monitoring: Any user or user application can place a ***constraint*** against any FD requesting notification should the constraint be violated. Constraint monitoring and exception notification is performed by CLCS system software at data rate speed thus allowing every sample of data to be screened. Both standard and fusion FD's can be monitored. This permits End Items to be monitored with far greater resolution and reliability. Constraint examples include: a Test Application Script requesting all OMRSD requirements be monitored and reported for each system; a Test Application Script requesting Launch Commit Criteria be monitored for GLS; and a system's End Item Managers requesting that any deviations from the current commanded system state be reported.
CLCS will perform test, checkout, control, and launch of the Space Shuttle with advanced state-of-the-art technology. It will be the real-time hub of the KSC Shuttle Data Center and will communicate to the User regarding the status of Shuttle processing and launch countdown operations. An overall system-level block diagram is presented in Figure 5.2-1.

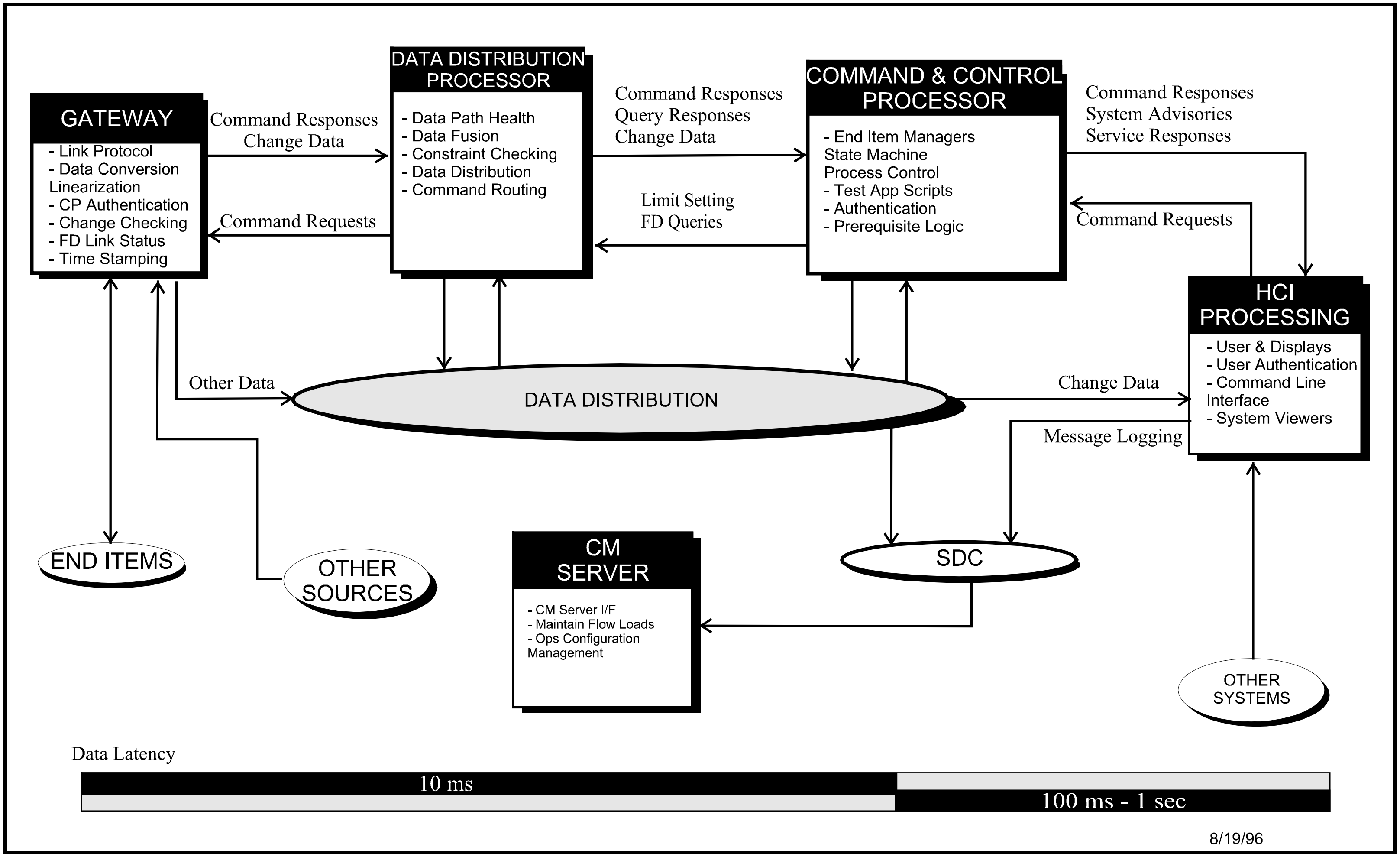

Figure 5.2-1 CLCS System-Level Block Diagram

5.2.1 Hardware Architecture

One of the driving forces behind replacing the existing CCMS is a desire to move away from custom-built, single-vendor-supplied, hardware onto Commercial-Off-The-Shelf (COTS) systems. The CLCS architecture is based upon COTS equipment with a few minor exceptions which are all considered to be extremely low-risk development items (keyboard switches, etc.).

CLCS is divided into three sections: a Front End Zone (FEZ) that contains the data acquisition equipment and other interface devices; a Control Zone (CZ) that contains the compute engines; and a Flow Zone (FZ) that contains the user workstations. These are illustrated in Figure 5.2.1-1. The FEZ and CZ are connected by a Real-Time Critical Network (RTCN), while the CZ and FZ are connected by a Display and Control Network (DCN).

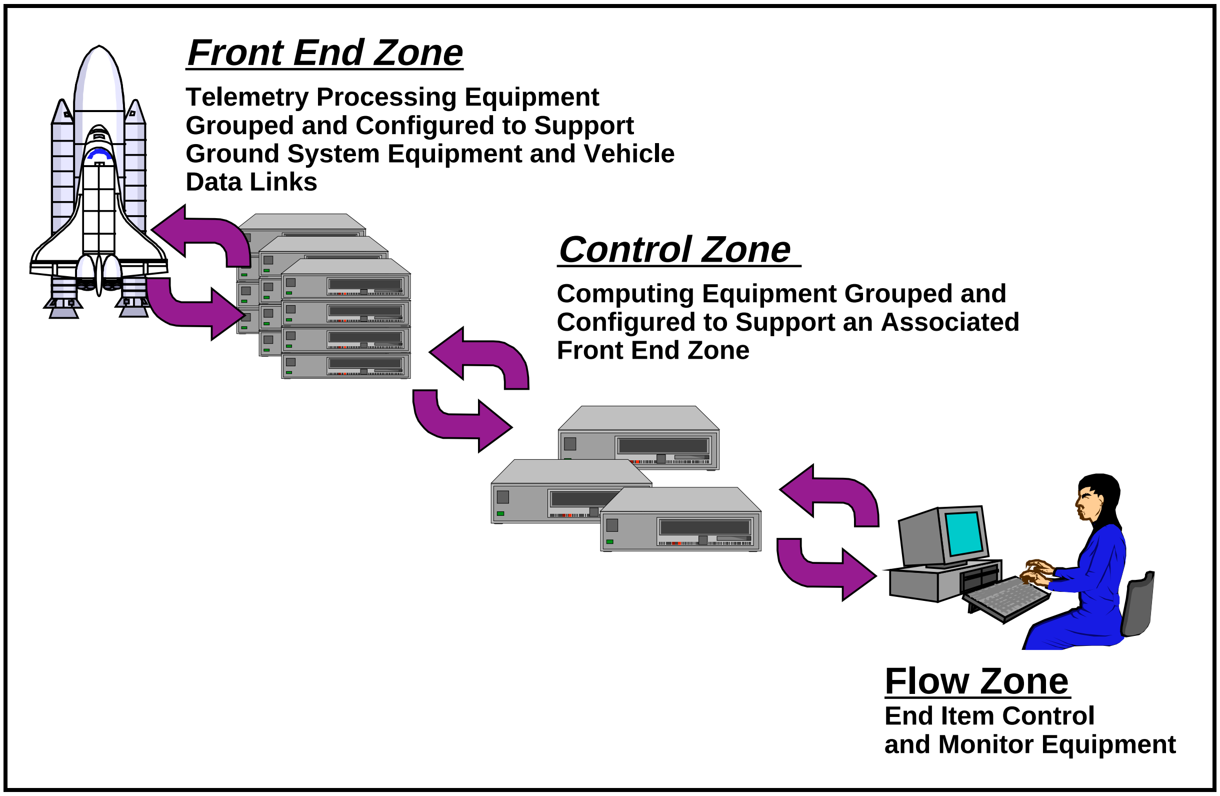

Figure 5.2.1-1 CLCS Equipment Zones

5.2.2 Software Architecture

A layered software architecture will be employed to improve safety, reliability, and quality. The system will deliver a higher level of knowledge than previously possible by including additional data, health, and status in the decision process. Vehicle configuration from other data bases (e.g., electrical connectivity) along with more complete definitions of valid system states will be combined to determine the actual end-item status. This final status will be much more reliable since all pertinent parameters are entered into the calculation.

In addition to improved reliability, a new constraint manager will enhance the sophistication of system control. This new constraint manager will provide surveillance over existing processes to enable appropriate action to be taken for system failures or unplanned excursions. All data samples of all pertinent data throughout the test will be utilized in lieu of selected or spot checks. The constraint manager will ensure that when a test is completed it met all the necessary criteria for successful completion. Discrepancies will be reported and handled prior to test completion.

System Software layering is shown in Figure 5.2.2-1. The Operating System will be COTS. System Services provide the foundation for system development. System Services include communication, data management, timing, logging, security, and network services. Application Services are the COTS and Custom tools, drivers, and special interfaces which support Application Software.

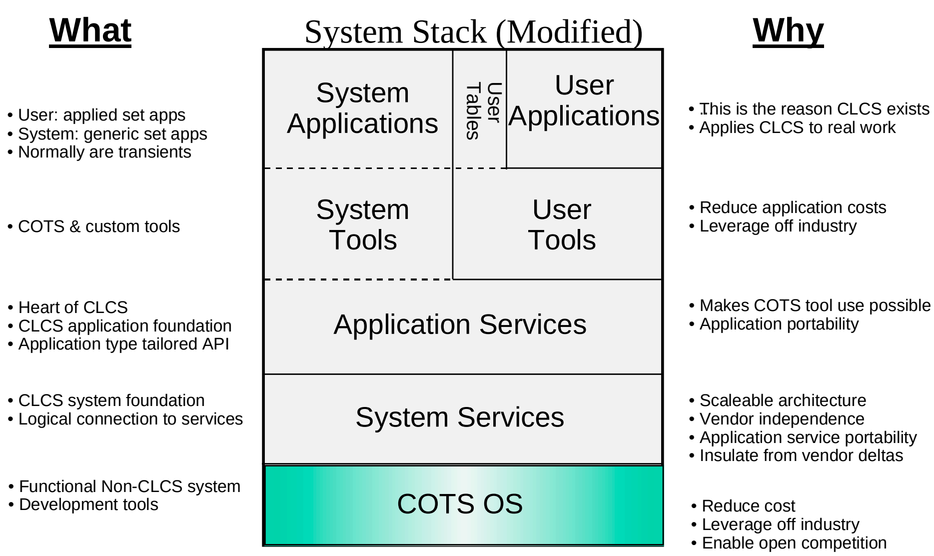

Figure 5.2.2-1 System Software Stack

Two types of applications will be supported, System and User Applications. System Applications are the applications that provide a service to multiple platforms. They include system utilities and productivity tools. User Applications are the applications which perform end item test, checkout, control, and monitor. The User Applications are tailored to support System Engineer Operators (one of the customers). User Applications provide user access and visibility.

The Figure shows the capabilities at each layer, built upon the layer below it. Also shown is the functionality contained in each layer.

The Application Software Organization and Stack is shown in Figure 5.2.2-2 and 5.2.2-3. The System Engineer Operator must have reliable monitor information available at all times as well as positive control over the end item under test. These primary functions of Launch Processing, control and monitoring, shown on the top application software layer are designed to meet the needs of the System Engineer Operator. A layered application concept will be employed to provide a safe and reliable processing system. The layered approach will also reduce the amount of ad hoc code. Functions needed by multiple applications will only have to be done once.

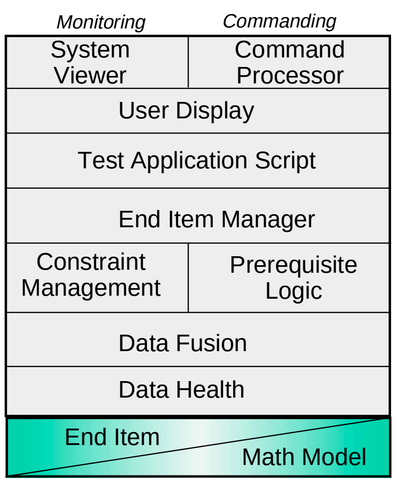

Figure 5.2.2-2 Application Organization

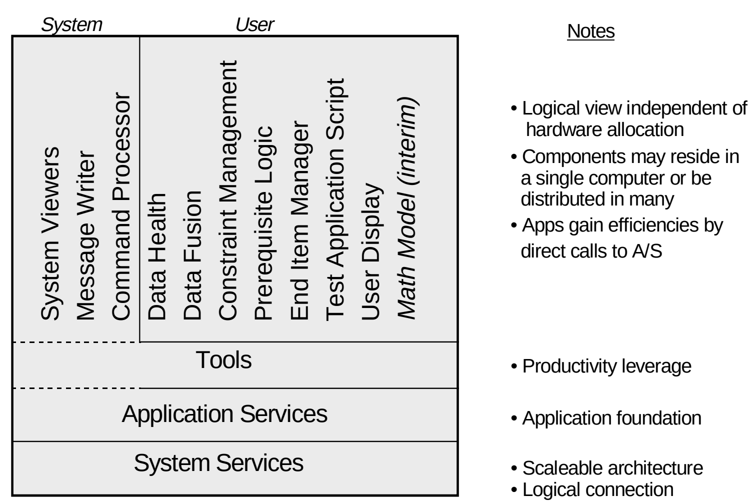

Figure 5.2.2-3 Application Stack

This approach will greatly simplify the overall system. Definitions for each layer follow:

Data Health: the reliability component of system and end item control. This includes communication path, data integrity, and component validity.

Data Fusion: the consolidation of all the attributes of the definition of a system state. For example, the state of a valve (open or closed) would be based upon commanded state, open and closed measurements, electrical connectivity, and system health.

Prerequisite Logic: the preliminary logic that must be satisfied prior to issuing safety critical commands. This is similar to current prerequisite logic, but will reside closer to the end item.

Constraints: the restrictions (e.g., end item control limits) that must be satisfied prior to completing a step in a sequence. Constraints are asserted and released to the Constraint Manger by other processes (User, End Item Managers, Test Application Scripts).

End Item Managers: the object oriented state based or process control application which controls and monitors test end items (e.g. Ground Support Equipment and Shuttle Vehicle Subsystems). An End Item Manager can receive notification from the Constraint Manger or a request from a user display, Test Application Script, or another End Item Manager. Reactive Control Logic procedures are End Item Managers with high (pre-emptive) priority.

Test Application Scripts: the sequence of events, or control procedure. It supports requests to End Item Managers, assertion/release of constraints to the Constraint Manager, prompting for manual steps to be performed, and requests to execute other Test Application Scripts.

Subsystem Displays: the display associated with a hardware end item. The display may be monitor only or may issue a request to an End Item Manager or Test Application Script for command and control.

System Viewers: a set of utilities which provide a standard viewer to display information on FD status, Test Application Scripts, constraints, data fusion, data health, and system configuration.

Command Processor: the command/control application or interface.

5.3 OPERATIONS CONCEPTS

5.3.1 Physical Characteristics

5.3.1.1 Flow Zone

Each Operations Control Room (OCR) and Multi-Function Room (MFR) is comprised of multiple Flow Zones, each of which can operate independently or be combined to performed larger or integrated operations. The Flow Zone is a CLCS concept which provides the capability to command, control and monitor multiple processing flows or TCIDs within the same control room. The control room is divisible into distinct areas for each Test Configuration Identifier Document (TCID)/processing flow. Command paths are logically isolated to those areas which support that flow. The area will contain physical indicators (i.e., signs, display headers, etc.) as to which flow an operator is working on and is reconfigurable on an as needed basis to provide sufficient consoles for testing associated with the flow. Sufficient storage assets and table surface area will be provided for auxiliary data, books and listings. Storage assets may be movable to facilitate area reconfiguration. The area will provide sufficient output assets (printers, faxes, copiers, strip charts) to prevent interference between the systems testing within a flow and between Flow Zones.

5.3.1.2 Specialized Processing Sites

Specialized Processing Sites are defined as areas outside the LC-39 area where CLCS activities will be performed. These include the HMF, CITE, SAIL, and DFRC. These sites will require both Systems Engineer and test conductor type consoles to support testing requirements. CLCS will have the same capabilities at these sites as identified for the LCC.

5.3.1.3 New Operations Control Rooms

The new Operations Control Rooms (OCR) (see example in Figure 5.3.1.3-1) are CLCS areas capable of providing command, control and monitoring of an integrated vehicle from the start of the Shuttle Interface Test through Terminal Countdown and Launch or Abort/Safing and Scrub/ Turnaround. The room is also configurable into multiple Flow Zones to support multiple flows if necessary. Typically, a control room will only be divided to support two non-integrated flows. An entire control room will normally be designated to support the prime vertical flow.

The area will be made up of 26 systems engineering type consoles, and 12 test conductor type consoles. The area will provide sufficient hardwire links to safe the vehicle and its environment (Pad, OPF, etc.) completely independent of CLCS. The area will provide dedicated printer/hardcopy support within headset cord range of all positions. Sufficient storage assets and table surface area will be provided for auxiliary data, books and listings.

- **Provides Opportunity For Engineering Sub-System Restructuring**
- **Allows for Better Space Utilization**
- **Supports Back Row Information Systems**
- **Requires Smaller Support Equipment Room (Common Equipment Area)**
- **Includes On-Site Shared I/O Area**

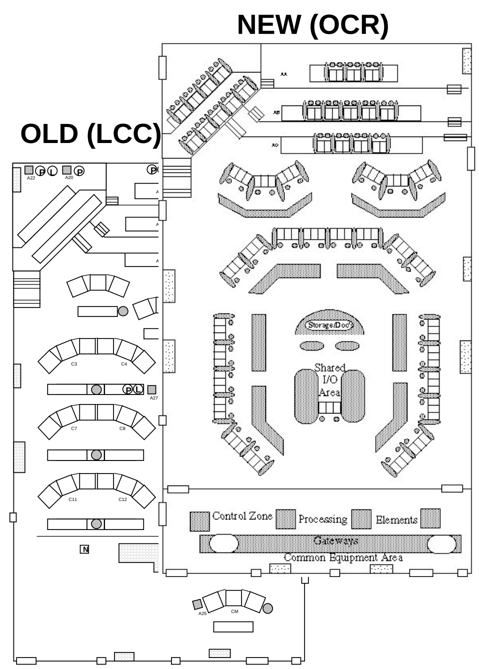

Figure 5.3.1.3-1 Example of Operations Control Room Concept

5.3.2 Local Operations Definition

Hands on, face to face communication with on-site personnel is an important improvement to operation control. A useful tool is the ability to have an engineer on the floor to directly experience the flow of a test, monitor operation of the equipment with its response to commanded states, and on-site command of troubleshooting. There is no intention to establish satellite control rooms, the purpose of local operations is to eliminate the need for having two engineers support a task, and closer coordination with the technicians working the job.

It is important to note for cost/benefit reasons that of the 600 LPS interfacing OMIs in use today, approximately 60% contain operations requiring engineers collocated in the field and in the control room. Local operations can certainly provide some pay back in the form of manpower savings.

CLCS ‘local operations’ will include the ability to monitor and command flight and ground hardware from multiple places in all processing sites. This will be implemented by extending the ‘Real-time Data’ and ‘Command Control’ networks to all processing sites. Each site will have network connections installed near vehicle processing locations. The number of network connections will initially be limited to key locations such as: in the crew module, near the aft access door, on the floor of the OPF, in the PTCR. Over time additional network connections can be installed to meet specific Engineering requests.

Normally, all network connections at a local site will be enabled for monitor only. The engineer will connect their workstation and log-on. If, as part of this log-on, command capability is needed (limited to the activity authorized for that location), validation by the Test Conductor would be required.

Portable workstations will be procured that can plug in to the network connections to provide monitoring and command capability. These work stations will only provide a limited set of the capabilities of an LCC workstation. The portables will be sized to provide telemetry, command, and limited advisory systems access. They will not be required to support OTV interfaces or access to the business information systems.

Full telemetry monitoring and limit checking will be supported on the local stations.
Both single command and command sequences will be supported. We accept that there will be some delay in command transmission/response times, therefore, time critical commanding does not need to be supported.

Use of local consoles for hazardous operations will be limited. Local control of operations will not be allowed if loss of command capability increases the hazard, or if potential exists for a hazardous area to expand to include the control location. Restrictions also apply for operations requiring multi-system integration/coordination.

5.3.3 Access Control

Physical security should not be any less than what is currently available in the existing CCMS. CLCS system security will not be compromised in order to achieve wide access. All attempts to access the system (successful or unsuccessful) and other security violations should be displayed to the Master Console and/or NASA Test Director console in message form and logged for traceability. Sufficient security validation and verification procedures should exist for access, command issuance, configuration changes, and data integrity.

In order to provide sufficient system security for CLCS, a log-on capability should exist but must be minimized. Safety should not be impeded by access controls. Log-on needs to be constructed to provide proper user permission levels, but no preset conditions need to be associated with a particular user ID. The test conductor in charge of the test should receive a screen message that a user has logged-on. Test conductor authentication of a log-on is only required for local commanding operations. When a shift change occurs the next user should be able to log-on over the previous user; no log-offs should be required and no CLCS actions should occur.

In order to support the additional time required to log-on to the console both operations and engineering require that CLCS support:

1. Single log-on allowing access to all network resources available in CLCS.
2. Users must be allowed to log-on to multiple consoles (up to 10) and multiple users (minimum of 4) should be able to log-on to a single command location.

5.3.4 Control Room Configuration

The physical layout of the workstations needs to clearly delineate the console grouping. All Operational Control Rooms and Multi-Function Rooms will be setup to allow the room to be divided. It is intended to group consoles supporting a specific TCID in a designated area within the control room allowing maximum flexibility in the use of hardware and personnel and reducing the number of idle consoles. Consoles will be assigned to a particular TCID for command and control capability.

5.3.4.1 Set Configuration

As many safeguards as possible should exist to ensure proper set configuration. Hardware configurations should be checked and validated by software all the way to the end item for that test configuration. Software should be available to monitor the configuration at various levels including the set, subset (Flow Zone), user positions, and individual components. This software should provide configuration information about the TCIDs loaded in each subset, each user application set, overall resource sizing information, all network components, etc. All configuration information should be recorded.

5.3.4.2 Set Load

In order to reconfigure a set from one TCID to another in a reasonable time, multiple TCID storage and automatic load capabilities are needed. Several versions of system software and application packages (TCIDs) may be stored at the SDC. During the pre-load process, the Activity Manager software will retrieve the operating system software and the applications software for the appropriate test configuration from the SDC and transfer it to local application servers. Upon successful initialization of subsystems with system software, the application set required to support testing may be made automatically available to the user from the local applications server upon successful log-on.

5.3.5 Data Access

Real-time data network access will be available to all areas; including all flow zones, control rooms, OSB, local sites, and processing sites. There should be no restrictions on shipping data to any NASA or Contractor facility. Access to the command network will be restricted to control rooms and dedicated LC-39 local sites only. The business information systems that will be provided must be isolated from the command and real-time data networks. This interface may differ from site to site (e.g., LC-39=SODN, CITE=PON)

5.3.6 Console versus 'Position'

5.3.6.1 System Engineer Consoles

Under the CLCS concept, the definition of 'console' changes somewhat. Consoles become generic pieces of hardware that can support any engineering discipline's testing on any given day. We envision disciplines still being consistently grouped within a control room for ease of identification and for access to their storage space.

The concept of a 'console' is comprised of three keyboards and five monitors (see Figure 5.3.6.1-1). Of the five monitors, only two will be capable of initiating commands. The other three monitors will be for real-time data and information systems, and at least one of the three will be multi-media capable. There will be a dedicated area on the console for OIS-D, safing panels, and other institutional legacy type equipment. This console can act as one or two distinct positions.

Engineering disciplines will have unique command application sets. Any console position should be capable of running at least four of these command applications sets simultaneously without significant loss of performance. Engineers should also be able to command a single application from multiple positions.

The system should only require one set of displays to be built for all command and monitor functions to keep from maintaining more than one display for each function. For example, in the current architecture, the command and control displays, PCGOAL displays, and ESA displays are all different. In the future, these displays should be one and the same. There will be two distinct type of displays; those associated with the command and control applications and those that are monitor only displays. All displays should be available on any monitor.

In addition, all systems within a flow zone should be given the capability to view any command display without risk of sending an inadvertent command. This includes viewing command displays for another system from the command monitor of a different system.. There is a requirement for the ability to restrict commanding to a specific system or group of systems. In addition a minimum two step process to execute a command in the application software is required. Software standards should be written to preclude automatically issuing commands or setting limits when an application is called up, rather these should be initiated by some operator action.

If we continue to do business the way it is done today, management and support personnel will reside in an operational environment for launch (i.e., LCC-2 is used today). These personnel should be able to view the same displays on their command screens that are being viewed on the launch room command screens, but be restricted from initiating commands.

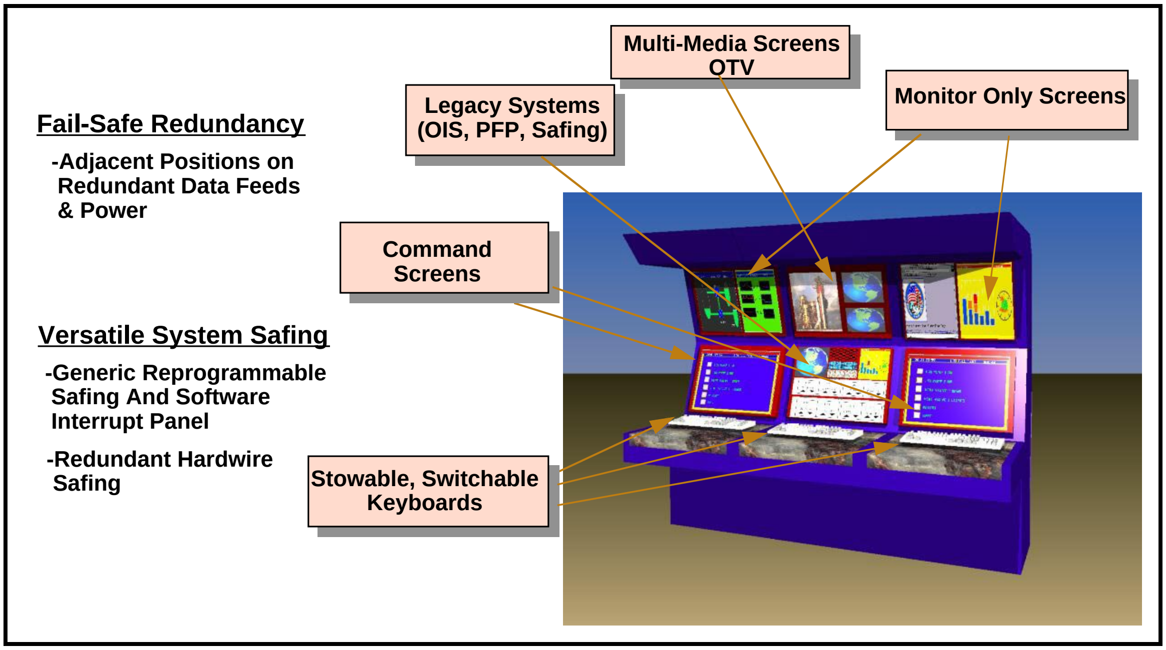

Figure 5.3.6.1-1 Typical CLCS Console (Conceptual)

5.3.6.2 Test Director/Conductor Consoles

Test Directors and Test Conductors serve a purpose in the firing room unique from that of systems engineers. Provisions must be made in these consoles for such things as expanded OIS-D and OTV capability, RF OIS-D and ICOM capability, Astro Comm panels, paging & area warning systems, GLS hold switch, emergency camera panel, bird deterrent panel, and multiple phones. There are no differences that represent system architectural drivers since these consoles require access to the same networks used by systems engineers.

There are, however, different configuration requirements for the TC consoles based on specific job functions. Some of the TC consoles should have the capability to enable or disable local network connections and to alter real-time control room configuration during day to day operations (i.e., increasing or decreasing the number of workstations in a flow zone). In addition, certain TC consoles should have the same command and control capability of a system console.

5.3.6.3 OMR/OSR Consoles

Program and Center management support of launch countdown from the OMR and OSR will require a different console configuration than the rest of the firing room. This area should have access to the real-time data and informational data networks along with OTV and OIS-D. Each position will have a dedicated phone.

Only one OMR/OSR area will be built requiring a total of 36 positions. This area will be accessible from both launch control rooms.

5.3.7 Baby-Sitting Concept

CLCS must support a standard vehicle power up/down by INTG, ECLSS, EPDC, ISL and DPS as is done currently, but must also support the monitor and control of vehicle power, data and cooling including power up and down from a single console. The baby-sitting console should be capable of monitoring for other systems and executing an emergency vehicle power down. A console of this type will be required for each flow zone/vehicle and will be physically located in the flow test area.

5.3.8 Operations Redundancy Definition

The entire system will provide a minimum fail safe operational capability. CLCS must provide complete redundancy for command paths before it can be used to support hazardous operations. For the purpose of this plan the word hazardous means that the loss of CLCS during a test would increase the risk of injury to personnel or damage to hardware. The only exception to this will be the user display system in the console since adjacent positions will have independent power and data feeds. The system engineers also require that a console operator be notified in a means other than through OIS-D when his console or application has failed or stopped responding (e.g., the redundant position is notified of the primary position failure).

During transition, the first run of any hazardous or vehicle test using CLCS, old LPS will have the capability to take over the test should a problem occur. Switchability between old LPS and CLCS is assumed and essential in the transition to CLCS to minimize schedule risk.

5.3.9 Safing

Currently there are four different types of safing in use in the control rooms. They are: GSE hardwire safing, LDB safing, reactive control logic, and program safing through programmable function panels (PFPs). At this point in the design effort, because we do not have any experience base with CLCS, we are reluctant to eliminate the requirement for any of the safing systems in use today. Therefore some provisions must be made to incorporate some version of each in CLCS. Any proposed new safing systems to support CLCS should be simple, reliable, of justifiable cost, use off-the-shelf components, and support the ‘generic console’ concept.

5.3.9.1 Hardwire Safing

Currently, loss of LPS can cause loss of GSE or vehicle control capability for critical functions. Since these conditions will still exist in CLCS, hardwire safing panels in both OCR’s must be provided to ensure a backup control system for emergency safing and securing if a significant loss of CLCS occurs. Appropriate emergency responses and safing actions should be available through a system wholly independent of CLCS and its support systems. The hardwire system should also have a means of continuously verifying its integrity. Sufficient hardwire links should be provided to support both integrated and non-integrated processing from either OCR, and sufficient links for non-integrated processing in the MFR.

5.3.9.2 LDB Safing

An LDB safing equivalent is required for CLCS to protect against command server and command path failures; although we anticipate that the CLCS architecture will significantly reduce the need for LDB safing by eliminating failures common to the current LPS architecture (i.e., console crash or buffer failure).

5.3.9.3 Programmable Function Panel (PFP)

In today's environment PFPs are used for sequencing tasks and executing safing sequences. Typically, GLS safing and other critical safing sequences are activated with a PFP keystroke. For this purpose, CLCS must provide labeled PFPs but not necessarily in the same form as today.

5.3.9.4 Reactive Control Logic

The functionality of reaction control logic must be preserved under the CLCS architecture.

5.3.10 Consolidated Data

The Consolidated Data Stream will be made up of HUMS, PMS, Shuttle Data Stream, RPS, Computed Values, and any other data streams utilized in the launch complex area. These data streams will be merged together much like the Shuttle Data Stream, often referred to as the PCGOAL Data Stream, is today. This data will be available everywhere on the network for monitoring purposes.

A new term that is introduced is 'Computed Values'. Computed values refers to computations currently done in GOAL or elsewhere. These values will be computed upstream based on other Consolidated Measurement data and the results of the computation will be placed into the Consolidated Data Stream for users to Monitor and Display.

Consolidated data will provide engineers the capability to bring off-line data analysis on-line to the operator real-time. In addition, to further automate subsystem testing we should work to allow certified consolidated data to drive a commanding sequence.

5.3.11 Operations and Maintenance Philosophy

The CLCS Operations philosophy is to operate in a modular and flexible environment with easy access to system resources. A rapid recovery and reconfigure capability should exist. It is desired that for every operation that can be performed manually today (setting Private Write Area [PWA] limits, making RCVS connections, etc.), that a remote automated capability exist in CLCS. It is envisioned that all configurations, loading, and initialization of all sets or subsets will be controlled from a centralized location (i.e. an Activity Manager function).

All system integrity functions should be controlled from one place (i.e. a Master function). The Master function should be capable of controlling redundant switchovers, and monitoring health and status of all hardware resources supporting a test configuration on an CLCS set. If the set is partitioned into several Flow Zones (i.e. multiple tests within the same physical

Control Room), then each Flow Zone should contain a Master function. The Master function should have the capability to be supported from any Workstation within the test configuration. The Master function should have a redundant standby switchover capability to ensure continued health and status monitoring and redundancy management of a test.

It is desired that a centrally controlled Maintenance Monitoring function exist. The Maintenance Monitoring function should have the ability to perform non-intrusive and intrusive testing on all subsystems within any set or Flow Zone. The maintenance repair philosophy for COTS components will be Return-to-Vendor (RTV). An in-house maintenance philosophy will be established to support any custom hardware.

The Shuttle Data Center (SDC) will be a central point of distribution and storage of all released software (system and application) required to load a CLCS set, and the storage of recorded data from the CLCS sets required for retrievals.

Since the CLCS architecture will be composed of several networks, a Network Management function will exist to control and monitor the CLCS networks and their interface to other networks.

It is desired that expert applications or utilities be available to support Operations and Maintenance functions (error analysis, memory dump analysis, etc.). To the greatest extent possible, all documentation to support Operations and Maintenance should be available on-line.

5.3.11.1 Network Manager Function

The Network Management function will be responsible for the management, configuration, and monitoring of all network components for networks supporting the CLCS architecture. This includes the access control of all networks outside of CLCS.

5.3.11.2 Activity Manager Function

All configurations, loading and initialization of a test configuration within any set or Flow Zone will be controlled by the Activity Manager function. The Activity Manager will be a centralized function and could exist outside the set environment. A test configuration will consist of the software and hardware components needed to support a test. The test configuration would be defined and stored in a centralized storage location (i.e. SDC).

The software will consist of the operating system, system applications, user engineering applications, as well as supporting tables, etc. that make up the test configuration software package (TCID). The application set would be built by the software development process and placed under configuration control prior to being loaded into an operational environment.

The Activity Manager would associate a set of gateways, processors and servers with a software test package. The Activity Manager would also configure a group of user positions to support the test configuration (TCID). The positions would access software specific to each engineering discipline via user log-on.

The capability should exist to pre-define a test configuration or activity and store in SDC. When a configuration is needed for testing, operations would activate that configuration and the system would autonomously configure and load the specified hardware. The capability to modify a test configuration real time should exist. A utility should be provided to the Activity Manager to verify the integrity of software stored on a server or loaded on a hardware platform.

5.3.11.3 Maintenance Monitor Function

The Maintenance Monitoring function will have the capability to perform non-intrusive and intrusive testing on all subsystems within any set or Flow Zone. If intrusive diagnostics is required to be performed on any equipment assigned to a set or Flow Zone, the Activity Manager function should restrict and grant access.

The Maintenance Monitoring function should have the capability to analyze logged system health and status data to predict probable time of a component failure. Failure data should be available to the maintenance personnel to aid in deciding which hardware is most likely to fail.

The Maintenance Monitoring function should have access to an on-line monitor/debug function to serve the system support personnel in troubleshooting hardware and software failures. The function should analyze the failure and based on historic data of the system, determine the failing component and recommend the appropriate action. This function also should give information regarding active users programs, active system programs or processes, status of all peripherals, and the date and time of the failure.

5.3.11.4 Master Console Functions

The Master function consists primarily of the system integrity function. The system integrity function performs the health and status monitoring of all hardware components allocated to a particular test configuration, and performs the redundancy management of all active/standby subsystems.

The system integrity function should monitor the state of all subsystems. It should validate system health, and based on system configuration, command active/standby switchovers for failed redundant components. Messages should be sent to the workstation displaying the Master function for notification of failed subsystems. Messages should also be sent to all subsystems in the affected set or Flow Zone, and to the SDC for recording. System integrity should also report on unexpected changes to subsystems (GSE bus errors, PCM format changes, loss of PCM data, etc.). Redundancy should exist for the system integrity function.

The system integrity function should have the capability to monitor both overall system health and status and detailed subsystem health and status. The detailed status should be operator selectable as to the level of detail. For example, the operator may only wish to see a subsystem’s peripheral error counts instead of the complete subsystem status. The health and status of each subsystem should be recorded in the SDC.

The subsystem error and status component should route messages to the workstation displaying the Master function. Each message should be tagged as to the set and subsystem that the message originated from, and the time of the message occurrence. The message may also contain the name of the software component responsible for the message.

5.3.12 Human Computer Interface (HCI) Definition

The CLCS HCI will replace the basic capability that CCMS provides today, which is to perform test and checkout of the Space Shuttle. CLCS will enhance information gathering, display, and analysis capability through the implementation of many new concepts and new features that will be demonstrated by CLCS in its early deliveries. Other new capabilities will not be provided until later in the development cycle. HCI Information Technology will be integrated into CLCS when it can be purchased off the shelf and provide a design solution for the needs of CLCS.

The CLCS console position will have access to a Command and Control CPU and network and to a Business and Information CPU and network from the same keyboard. A switch will be provided to enable this dual connection. The Command and Control CPUs will be isolated from the Business and Information CPUs. This isolation enables the user to have access to a broad range of Business Information Systems without degrading the Command and Control System’s performance or security.

An Experimental Control Room will be created to provide for HCI Information Technology evaluation from the beginning of CLCS development and continue after CLCS is deployed. The Experimental Control Room will enable users to evaluate new Information Technology that becomes available in the future for applicability to CLCS.

5.3.12.1 Multi-Media Options

OTV will be integrated with CLCS. The user will have access to OTV for viewing and control from a Business Information Systems position. Engineers will have the capability to control pan, tilt, zoom, iris, screen capture, sweep and other OTV camera features through a Graphical User Interface (GUI). For viewing, a camera sequencing function will be provided. The user will have the ability to playback OTV, including a slow motion option. There will be a feature to allow for the viewing and printing of screen captured images. There will also be a capability to display up to four OTV cameras on one monitor at a console.

Multi-Media headsets or earplugs should be available to support the audio portion of multi-media applications for the Business and Information CPUs. The sound from these speakers must not interfere with engineers at other consoles.

Microphones at console positions are not required for early CLCS. However, we must seize opportunities that become available in the future for microphone application to CLCS. Microphones could be used for recording dictated messages and observations during testing by engineers.

Mini-Cameras at console positions are not required for early CLCS. Eventually mini-cameras, microphones, and speakers/headphones could be used to support video-teleconferencing.

5.3.12.2 Communications

OIS-D will not be integrated into CLCS. Existing OIS-D resources including the hardware in the Control Rooms today will be used. There must be space in the console layout to accommodate this OIS-D equipment. As CLCS matures, OIS-D could become virtual for a listen only mode.

Standard telephone technology such as call forwarding, beepers, and telephone numbers assigned by system will be used to accommodate the flexible engineering seat assignments afforded by CLCS. As telephone technology improves and provides features such as video teleconferencing, the control rooms are expected to keep pace.

5.3.12.3 Input Devices

Switch vs. Mouse for keyboard CPU Assignment: A switch is preferable to a mouse for switching a keyboard between a Command CPU and a Business and Information CPU. The mouse provides a greater chance of accidentally making a change in the keyboard CPU assignment. The switch requires a positive operator action to change the keyboard CPU assignment. Current CCMS has a similar function, the switch made up of the ‘CDS ENABLE’ key and the ‘CPU ENABLE’ key. CLCS will provide one advantage in this switching area over today’s system. In CLCS when a user switches to the Business and Information CPU, the user will still be able to view the Command CPU’s screen.

Programmable Function Panel (PFP): PFPs are still needed. Engineers do not feel comfortable trying to use a mouse to perform emergency safing sequences. They prefer a push button action for performing these programmed sequences. The PFP should be associated with the active window of the command and control position. If the user presses the key that switches the keyboard to the Business and Information CPU, the PFP will remain attached to the last active window on the Command and Control CPU. This allows multiple disciplines to share a PFP.

We do not have enough information at this time to decide whether a PFP should be a panel or a touch screen. We feel that both should be evaluated, and that console real-estate should be considered in making this choice.

Hardwire Safing: Hardwire safing should be implemented in a manner which allows consoles to remain generic. A new generic safing panel will be designed. The console will have a port to accept a safing panel. The port will be connected to a non-CLCS network which will be connected to the old hardwire safing system running from the LCC to the site. Panel overlays can be used to help keep the new safing panel generic. The power and networks for the hardwire safing system must be separate from CLCS and have its own redundancy.

Keyboards: Standard keyboards should be used. The standard keyboard function keys can be used as a functional replacement of our Programmable Function Keys that we use today. The keyboards should contain a numeric keypad, a minimum of 15 function keys, and be capable of accepting a keyboard overlay.

Pointing Devices: A mouse is an acceptable pointing device for CLCS. A three button mouse is required for accessing applications on systems which utilize a three button mouse. Other pointing devices such as a track ball, and touch pad should be considered for application to CLCS.

Electronic White Board: We envision an electronic ‘white board’ capability on the Business and Information Network. This would allow an engineer to annotate on their CRT with an electronic pen a problem for others to view on their CRT.

5.3.12.4 Output Devices

Auxiliary ports will be provided at each console with access to power, Business and Information Network, special peripheral devices such as strip chart plotters, special keypads and safing panels. There will also be auxiliary ports to accommodate the Launch Back Row Information System. SDC data retrieval capability will be provided from the command monitor at CLCS consoles.

The Common I/O area or Data Review Room within a Control Room should have two combination scanner/fax machines and two black and white laser printers and one color laser printer.

Each console should have one black and white laser printer. There should be one scanner/fax within headset cord reach to allow bringing hardcopy on-line. ‘Within headset cord reach’ equates to one scanner/fax for two consoles.

5.3.13 Local Operations

Today many hardware tests require engineers to be located in the control room and at the site of the test. The local laptop capability is an attempt to enable engineers to perform tests at the local site and eliminate the need for an engineer to be present in the control room to support the test.

Laptops will be used at local sites such as the OPF and PAD for access to Command Control and Monitor data. These laptops will be under Configuration Control. These laptops will not have access to the information network. They will have access to data retrievals. These laptops will run the same software that is run from a Control Room Command Position.

5.3.14 Launch Back Row Information System

Today engineers in the back row during launch have very little access to data. They have no computer or keyboard to grant them access to the wealth of information assembled during the life of the program. The creation of a Launch Back Row Information System will allow engineers that sit in the back row during launch to have access to Business, Information and

Monitor Data. This data access capability should help these engineers be even more effective in carrying out their engineering role during launch. Selected engineering positions in the back row will be provided with laptops to provide them with information. These laptops will have access to Business, Information and Monitor data. They will not have access to the command network. These laptops will be under Configuration Control. These laptops will run the same software that is run from a Control Room Business and Information Position.

5.3.15 Simulations

Stand-alone simulation capabilities will be accessible from a control room console as well as an office workstation. This will allow a large quantity of training and software debug to occur without impacting vehicle testing. In addition, if a problem is found during current testing, there is no method by which simulation can be used to explore a work around. A ‘What If’ scenario capability would provide a method to explore the feasibility of a work around real-time at a control room console. This capability would augment real-time trouble shooting while providing training and confidence building.

5.4 TRAINING

Training should be provided for all system tools incorporated. Specifically, users must be trained in writing software, coding their applications in a new language, and in the capabilities of the CLCS system.

An important aspect to the education process will be on-the job training. As users develop new applications and run them against the math model for debugging they will continue to gain experience with system hardware and software tools.

Simulations will still play a very important role in training. Along with formal integrated simulations like S0044 and S0056, desktop simulations will provide additional opportunities for training at the individual level.

6.0 TASK DESCRIPTIONS

6.1 IMPLEMENTATION APPROACH

Strategic Engineering is the process of developing and disseminating overall program goals to the developing organizations. These provide guidance for the designers and developers to ensure they are cognizant of the fundamental direction the project is headed.

CLCS progress is based on six month product deliveries. Each incremental delivery provides a system capability and builds on the previous capability. The CLCS System Thread is a tool that is used to describe a delivered capability from a software development standpoint. The thread represents the interwoven hardware and software products that provide an incremental capability. Figure 6.1-1 illustrates the product, thread, capability and delivery relationship.

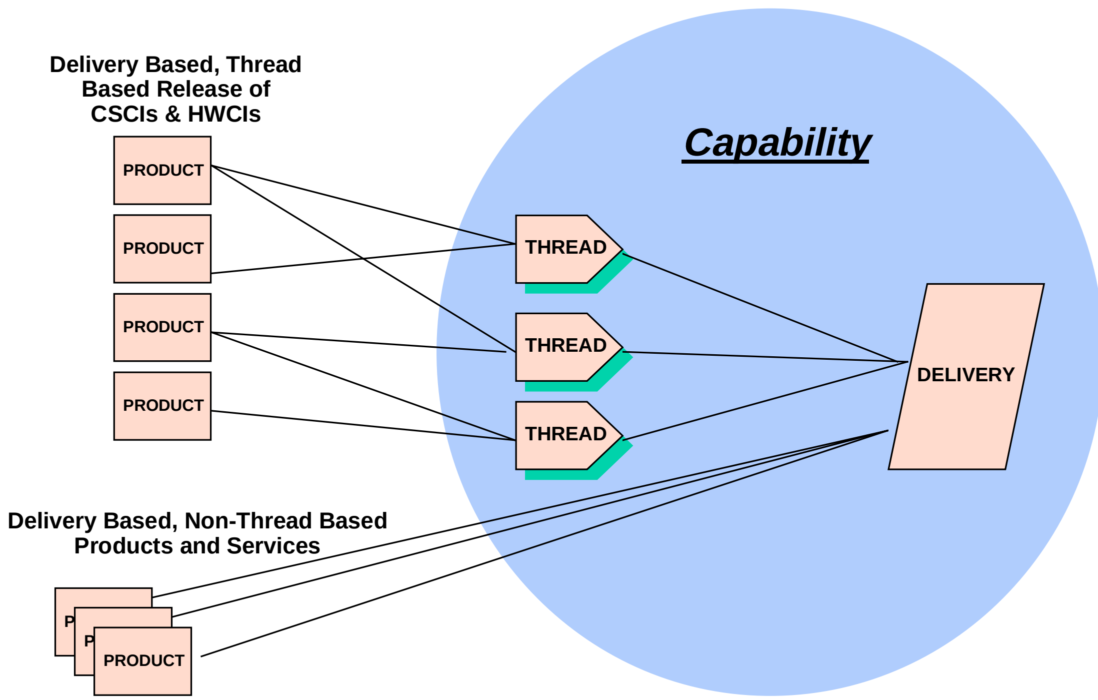

Figure 6.1-1 Product, Thread, Capability, and Delivery Relationship

6.2 TRANSITION PLAN

Figure 6.2-1 illustrates the basic CLCS Buildup and transition sequence. With the transition of LCC-4 first, the manifest will continue to be supported by LCC-1, 2, and 3. These Control rooms will be able to support four parallel flows; two vertical flows and two horizontal; or three horizontal flows, and one vertical. This can be accomplished by dividing LCC-2 to support two TCIDs for two OPF flows. LCC-4 hardwire panels and some back room equipment must be moved into LCC-2 for it to be capable of supporting two vehicles during horizontal flows. This plan minimizes any manifest risk since the control room conversion is based on successful certification of one room before another control room is converted.

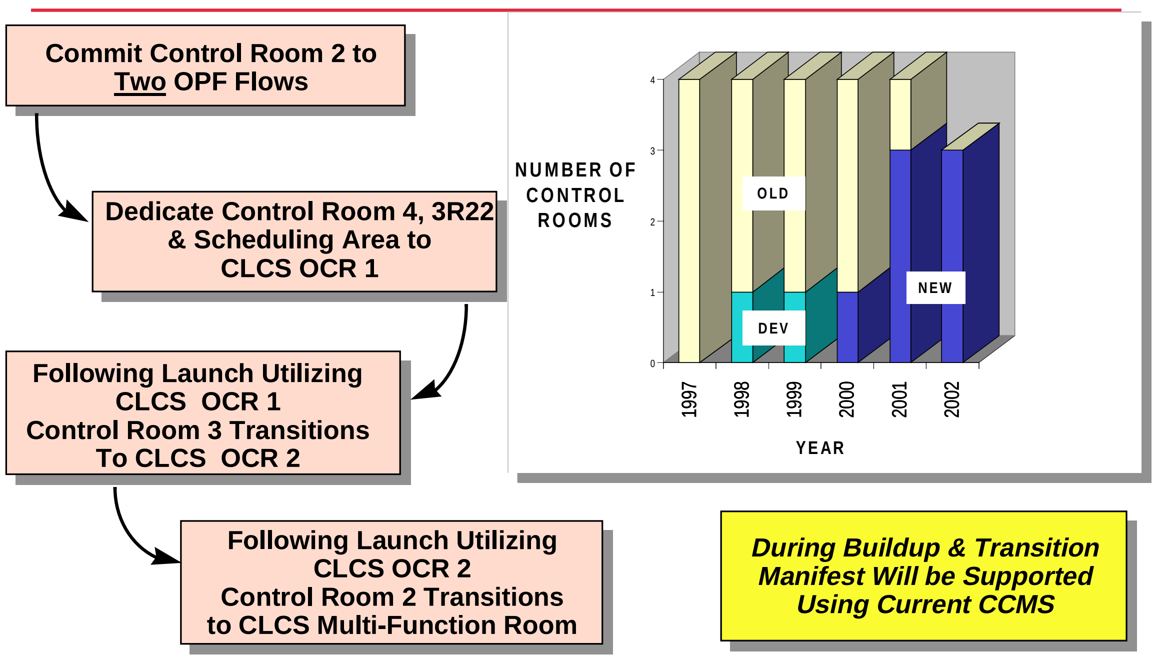

Figure 6.2-1 CLCS Buildup and Transition Sequence

6.2.1 INITIAL CLCS ACTIVATION

Initial equipment deployments will be into the LCC 3P5 (Control Room 2 bubble) and 2R23-25. There will be two areas termed the LCC-X and the Integrated Development Environment (IDE). These areas will provide the initial build a little, test a little environment. The LCC-X area will provide for initial HCI and consolidated data demonstration. IDE will be the promotion area for system software and applications before they enter an operational environment. Various Satellite Development Environments (SDE) will exist in locations convenient to the developers.

6.2.2 LCC-4 TO OCR-1 CONVERSION

3R22, LCC-4, and the front glass area will be converted to the first CLCS Operations Control Room. During its conversion, LCC-4 must support CLCS application certification against flight hardware and GSE on one side of the room while application development/conversion continues on the other until all OPF, Pad and GSE applications are converted and certified for operational use. Some CLCS operational capability will be gained before all applications are converted, but only half of the room could actually be committed to operational use because of the need for application certification space.

LCC-1, 2, and 3 will remain intact until the OCR-1 is certified fully operational for horizontal and vertical processing including launch.

6.2.3 LCC-3 TO OCR-2 CONVERSION

Upon OCR-1 CLCS certification, LCC-3 will be converted to a second CLCS control room with sufficient assets for full training simulations and wiring for full vertical flow operations including launch. LCC-1 and LCC-2 will remain intact until OCR-2 is fully certified.

6.2.4 LCC-2 TO MULTI-FUNCTION ROOM CONVERSION

Upon successful launch from OCR-2, LCC-2 will be converted to a Flow Zone facility (OCR-3), to include the Complex Control Set (CCS).

6.2.5 FINAL TRANSITION

Upon OCR-3 certification LCC-1 can be taken off line. Sufficient assets will be available in CLCS to process four vehicles; two vertically. The LCC-1 area can be allocated as the continuing technology area if required.

6.3 PROJECT SUMMARY WORK BREAKDOWN STRUCTURE (WBS)

The CLCS project has developed a detailed Work Breakdown Structure (WBS) that functionally divides work into discrete, logical tasks. Budget and schedule have been defined for each task. There is a responsible NASA end-item manager responsible for budget and schedule associated with each task. The project-level WBS is illustrated in Figure 6.3-1.

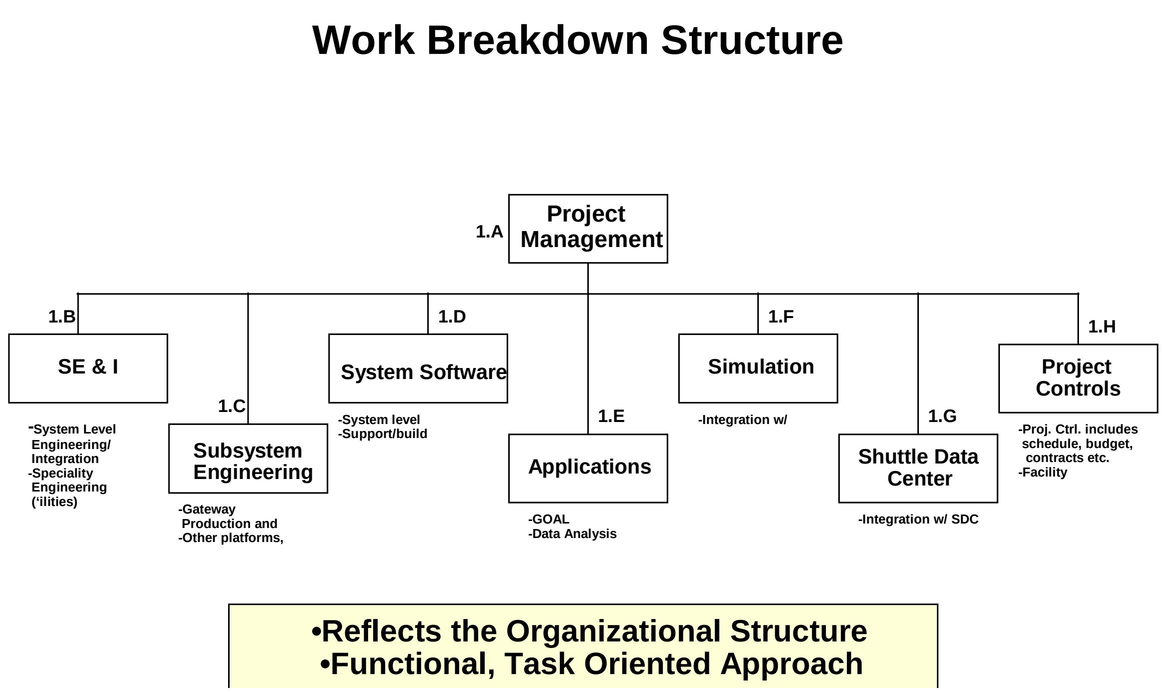

Figure 6.3-1 CLCS Project-level WBS

7.0 PROCUREMENT SUMMARY

CLCS project is to replace Shuttle control room systems with state-of-the-art commercial equipment and software. The CLCS concept takes full advantage of modern methodologies and Commercial Off the Shelf (COTS) hardware and software. This will reduce operations and maintenance costs; allow inclusion of new interfaces to support Shuttle upgrades and new programs; improve system reliability, flexibility, and supportability; realize Shuttle processing efficiencies; allow system to keep pace with new technology, and eliminate proliferation of computer systems in the control rooms.

Existing contracts will be used as required to obtain contractor support:

- NAS9-20000 Space Flight Operations Contract (JSC)
- NAS9-18300 Mission Support Contract (JSC)
- NAS10-11943 Engineering Support Contract (KSC)
- NAS10-11400 Payload Ground Operations Contract (KSC)
- NAS10-12000 Base Operations Contract (KSC)

NASA direct buys for hardware required to support the project:

- Build on commercial and industry standards
- SEWP (Goddard), PCAC (KSC); NASA Consolidated Contract Initiative
- Open competition for build-to-print production items (e.g. Gateways) and items not available through SEWP

8.0 SCHEDULES

8.1 CRITICAL PATH

An analysis was performed which identified application software, its testing, certification, and validation as the primary elements in the project's critical path.

8.2 PROJECT LIFE-CYCLE

The LURT study served as the "Pre Phase A Advanced Studies" for the CLCS Project. The Go-Ahead from this study initiated the 60 Day Pilot Project (see section 1.0) or "Phase A Preliminary Analysis". The primary products produced in Phase A were the *Management and Technical Volume* and a *Cost Volume* which together defined the project's baseline and included the description of the life-cycle approach, concept of operations, hardware and software architecture, implementation and transition plans, Work Breakdown Structure, and ROM cost estimates. Several reviews followed the completion of the 60 Day Pilot Project including an architectural baseline review and Basis of Estimate review (serving as the projects preliminary Non-Advocate Review) supported by key personnel from JSC's MCC project. Approval of start-up funding in October, 1996 initiated the "Phase B Definition" for CLCS.

CLCS has adopted the concept of incremental deliveries, i.e. ten small deliveries, one every six months. This approach ensures that the system is delivered, not paper/theory on what the system "should be". These six month drops are integral to the success and risk mitigation of the project. It allows for early detection of latent flaws, quick turnaround of system fixes, and provides early user review of the real system (not paper design). The results of this approach create an overlap among the remaining phases of the project's life-cycle as definition and design of one delivery will be concurrent with the development of another. In addition, CLCS replaces technology at over 10 different sites, several with their own unique requirements. Some deliveries will lead to sites becoming operational while other deliveries are entering previous phases.

MIL-STD-498 describes the development process and the reviewing techniques for both incremental and evolutionary type projects. CLCS represents a hybrid of these two types of projects. CLCS will meet the intent of and tailor appropriately the reviews discussed in MIL-STD-498 through system level and project level reviews and in particular the design panel process.

The Architectural Baseline Review (ABR) will establish the baseline for system level specifications and requirements will also serve as the baseline mechanism for many project level documents. Annual Project Plan Reviews (PPRs) are scheduled to clarify and review significant changes to system baseline requirements and to assure changes are to be implemented efficiently and that they support the project's critical milestones as identified in the CLCS Five Year Master Project Schedule. Preliminary and Critical Design Reviews (PDR and CDR) will be conducted prior to major system procurement activities.

Prior to the first complete CLCS Shuttle processing flow, a review will be conducted to provide the assurance that CLCS has no impact to flight elements.

A CLCS team is dedicated to defining the certification and validation process. This process will be a key element leading to the streamlining of system acceptance, safety readiness, flight readiness and operational readiness. The CLCS Project life-cycle is illustrated in Figure 8.2-1.

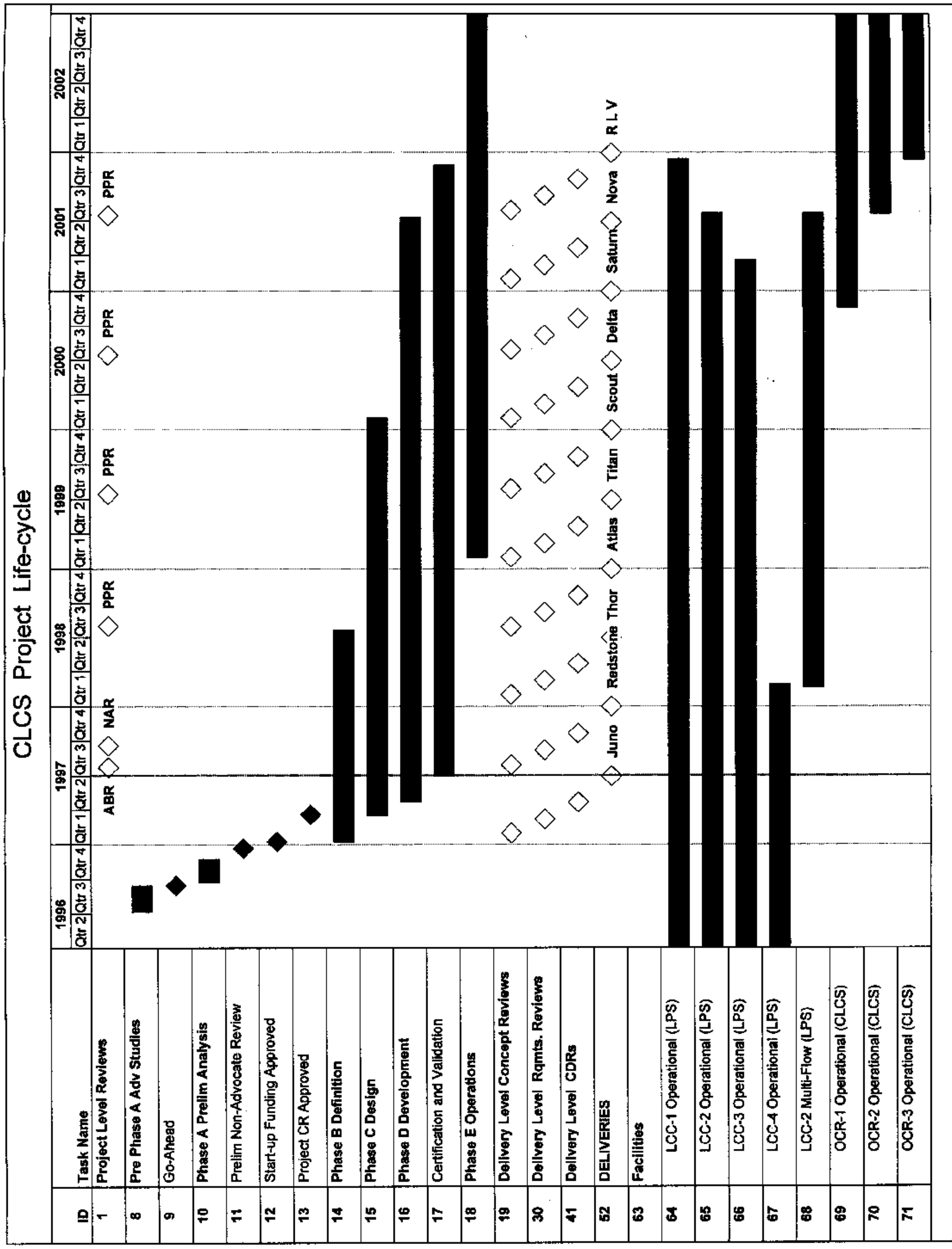

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Figure 8.2-1 CLCS Project Life-cycle

8.3 DELIVERY AND CAPABILITY

A delivery manager is assigned to each delivery. This delivery manager is responsible for collecting status and identifying issues and concern to the CLCS project management. Each delivery is critical to the next as they serve as building blocks each bringing additional capability with CLCS being launch capable in March 2001 and fully implemented by October 2001. Other milestones include orbiter powerup capability in March 1999 and orbiter pre-launch processing in September 2000. The five year delivery schedule is illustrated in Figure 8.3-1.

Development and implementation of the CLCS will result in a checkout and launch capability which will support through the end of the Shuttle program and which is easily adaptable to support future space vehicles and Shuttle upgrades.

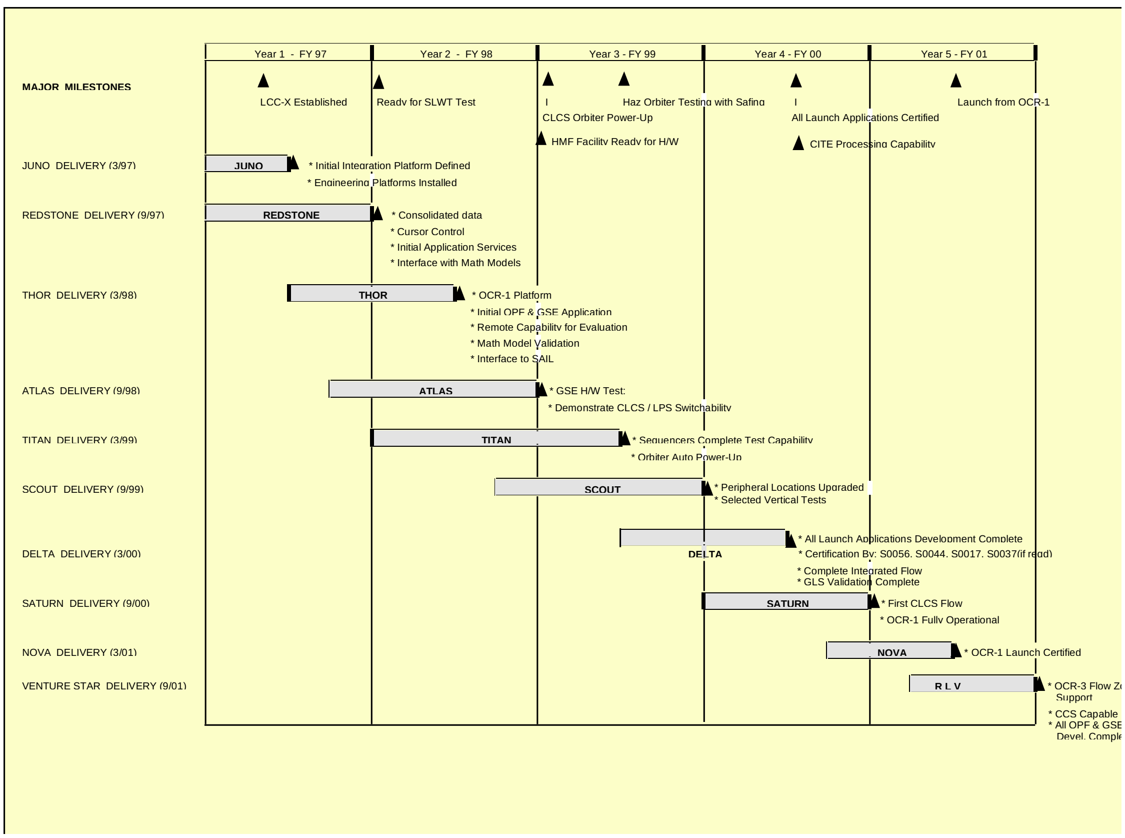

Figure 8.3-1 CLCS 5-Year Delivery Schedule

9.0 RESOURCES

9.1 FUNDING REQUIREMENTS

The CLCS Project will utilize both Civil Service and contractor resources as identified in Figure 9.1-1 below. Although modifications to existing facilities will be required, the CLCS project has developed viable transition plans enabling the project to avoid the construction of any new facilities.

	FY97	FY98	FY99	FY00	FY01	FY02	Total
Labor (FTE)	166	344	403	329	179		1421
Contractor	100	249	283	209	89		930
Civil Service	66	95	120	120	90		491
Contractor Cost	$10.0	$25.6	$30.0	$22.8	$10.0		$98.4
USA	3.2	7.6	11.5	11.8	8.1		42.2
LMSMS	4.8	12.3	12.0	5.4	0.5		35.0
I-NET	1.8	4.9	5.1	4.2	0.6		16.6
EG&G	0.1	0.4	0.7	0.7	0.4		2.3
MDS&DS	0.1	0.4	0.7	0.7	0.4		2.3
NASA Procurements	$11.7	$14.8	$21.1	$15.4	$10.0		$73.0
Total Cost (excl. CS)	$21.7	$40.4	$51.1	$38.2	$20.0	$0.0	$171.4
APA	$0.0	$0.0	$0.0	$8.0	$14.0	$12.3	$34.3

Costs Include:
Initial Spares
HW/SW Maintenance
Development Environment
Labor @100K/WY w/3% escalation
LCC Facility Mods/CCMS Removal
Installation & Activation
SDC, SIM, & Models Deltas
OMI Rewrite
Re-Certification
RCVS Replacement
Training, Travel

Funding: Shuttle Launch Site Equipment Upgrades (UPN 260)

Figure 9.1-1 CLCS Resource Requirements

9.2 INSTITUTIONAL REQUIREMENTS

Civil Service and contractor personnel will be used to directly support the CLCS project. The level of this involvement for Civil Service is identified in Figure 9.1-1.

As an example of achieving the goals of the project in the most expeditious and cost-effective manner, the CLCS Project plans to reuse the major facilities currently housing the existing Launch Processing System. Detailed transition plans have been developed and will further be refined in order to successfully transition from to CLCS with no impact to the manifest. Satellite Development Environments (SDEs), an Integrated Development Environment (IDE), and an experimental control room (LCC-X) will be utilized to support the development effort and to provide an environment for future assessment of new products and their potential in CLCS.

10.0 MANAGEMENT REVIEWS

10.1 PROGRAM-LEVEL REVIEWS

Program level reviews will be held quarterly (or as requested by CLCS PMC Chairperson) with the CLCS PMC to provide status and as required, to resolve issues or seek guidance. CLCS project status will also be reviewed with the Manager, Space Shuttle Program approximately every six weeks. It is intended that the reporting of CLCS status and issues will be weaved in existing programmatic processes.

10.2 PROJECT-LEVEL REVIEWS

Project level reviews associated with each delivery will be referred to as *design panels.* Each incremental delivery has its own design, development, and implementation process which more closely resembles the typical project life-cycle. Each delivery is made up of multiple products which when integrated together provide system capabilities. MIL-STD-498 describes the development process and the reviewing techniques for both incremental and evolutionary type projects. CLCS represents a hybrid of these two types of projects. CLCS will meet the intent of and tailor appropriately the reviews discussed in MIL-STD-498 through system level and project level reviews and in particular the design panel process.

The Architectural Baseline Review (ABR) will establish the baseline for the system level specifications and regulations, and will also serve as the baseline mechanism for many project level documents. Annual Project Plan Reviews (PPRs) are scheduled to clarify and review significant changes to system baseline requirements and to assure changes are to be implemented efficiently and that they support the project’s critical milestones as identified in the CLCS Five Year Master Project Schedule. Preliminary and Critical Design Reviews (PDR and CDR) will be conducted prior to major system procurement activities.

11.0 CONTROLS

11.1 CHANGE / CONFIGURATION MANAGEMENT

The CLCS Configuration Control Board is responsible for the overall configuration control of CLCS baselines, including:

- Establish and control the requirements baseline for the CLCS.
- Provide change authority for baselined CLCS system and application software.
- Provide change authority for baselined CLCS hardware.
- Establish and control project schedule, which includes CLCS software release schedules.
- Control project costs due to changes in requirements.
- Disposition internal change paper written against CLCS configuration-controlled hardware and software.
- Disposition internal change paper with requirements that potentially affect other organizations/functions to Control Boards for those organizations/functions.
- Disposition change paper received from Control Boards of other organizations/functions.
- Elevate to the PMC those changes which affect program level requirements or are not within budget or schedule.

Additional definitions, roles, and responsibilities are identified in the CLCS CCB Charter, (84K00006) and Configuration Management Plan, (84K00052).

11.1.1 DESIGN CONTROL

Project level design and development planning occurred during the preliminary phases of the project's life-cycle. The products of the 60-Day Team provide the baseline for the CLCS Project and it's proposed hardware and software architecture. CLCS will be delivered incrementally with a delivery each six-month. After the first delivery, subsequent deliveries will provide additional capability built on the previous. In essence, each delivery will be treated as a smaller project with its own planning, design, development, and implementation phases. CLCS Design Team reviews will provide the means to establish and document the requirements and implementation approach (architecture) for each delivery. This documentation will be reviewed for accuracy and approved by authorized personnel (internal - Leads from System Engineering and Integration, System S/W, Subsystem Engineering, Application S/W, Simulation, User Liaison, and Project Controls) and will define the delivery baseline. Changes to this baseline will be reviewed and approved by the CLCS Configuration Control Board, CLCS CCB.

11.1.2 DOCUMENT AND DATA CONTROL

Documents and data that relate to the CLCS Project will be controlled to the extent necessary to ensure a quality product and to meet configuration management requirements. Design documents and data (i.e., drawings, specifications, and other technical data) associated with the project will be reviewed and approved by the CLCS Design Team (internal) and shall meet the appropriate documentation standards. Changes to documents and data will be reviewed and approved by the same functions/organizations that performed the original review and approval. The development documentation baseline is controlled by the design panel chairman. Release of revisions to project level documentation will be authorized by the CLCS CCB.

11.1.3 DELIVERY CONTROL

As each delivery is a building block for the next, CLCS Project deliveries will be controlled to ensure a stable platform to support continuing development, integration, and testing. Each delivery and accompanying documentation will be reviewed for accuracy and consistency through the design panel process, and will be approved by the design panel chairman (internal). When continuing development requires changes to the configuration previous delivery, change approval will be performed by the same functions/organizations that performed the original review and approval.

11.1.4 CONFIGURATION MANAGEMENT ON OPERATIONAL CLCS

Once a CLCS component/set is validated and certified for operational support, configuration management and change control is no longer internal to the project. Configuration identification, control, verification, and accounting will use a formal system for processing changes to the current configuration baseline, dispositioning these changes by Configuration Control Board Directives (CCBD’s), closing out the CCBD upon verification of change implementation.

11.2 KEY PROGRAM PARAMETERS

Measuring cost and schedule performance of the project will serve as a valuable tool for achieving the optimum balance and managing the CLCS Project, identifying successes as well as potential problem areas. It is intended that the Performance Measurement Tool(s) (PMT) used in the CLCS project will enable Project Management to prepare a brief but accurate report as an insight to the overall performance of the project. In general, cost and schedule performance will be measured and finally cost against schedule.

Cost and schedule data will be analyzed against two sets of planning data. 1) In-depth project planning was performed by the Initial 60-Day Team. This data has been reviewed and scrubbed several times over and the resulting data has been used to establish the project’s cost and schedule baseline (Up-front Planning Baseline - UPB). 2) The system being developed by this project will evolved from incremental deliveries. These deliveries are intended be made approximately one every six months over the five year period, totaling 10 deliveries. Each delivery will have its own mini design, development, and implementation cycle. During the “kick-off” of each delivery cycle, detailed delivery planning will be performed, updating cost and schedule plans accordingly. This revised plan will serve as updates to the baseline for cost and schedule performance analysis.

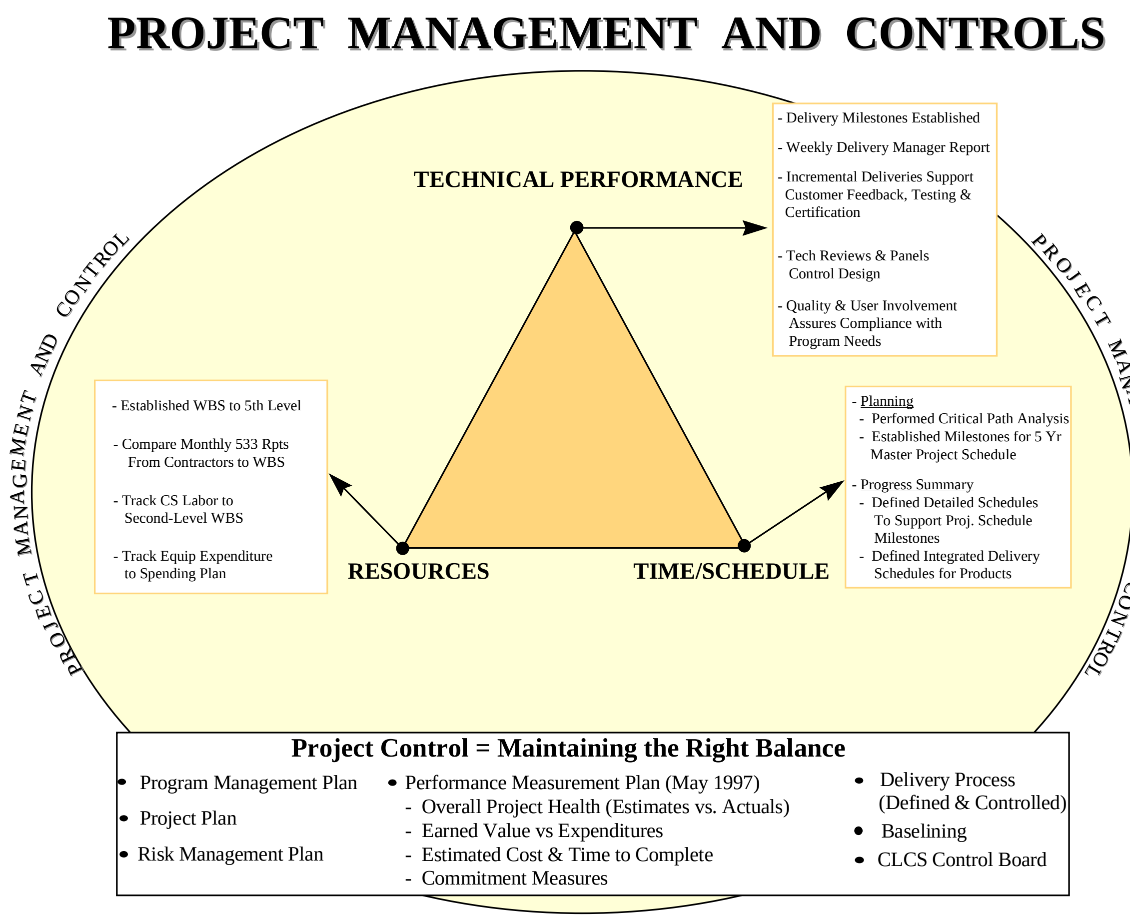

Figure 11.2-1 CLCS Management and Controls

Figure 11.2-1 illustrates the relationship between technical performance, resources, time/schedule, and management and controls. Additionally, this figure lists the major tools to be used in order to maintain the correct balance among these elements. Beginning with the second delivery, Sept. 1997, the CLCS Performance Measurement Plan will be used to assess cost, schedule, and technical performance. This data will be made available to the CLCS PMC and the Manager, Space Shuttle Program and will therefore serve as a tool to inform these elements on issues of the project's overall performance. Project Plan Reviews will be used to identify any significant changes to the overall system architecture which are required to most efficiently achieve the project's goals. The Performance Measurement Plan will also identify and establish measurements to monitor the progress towards achieving the commitments described in the Program Commitment Agreement (84K00007).

11.3 VERIFICATION OF REQUIREMENTS - CERTIFICATION

Although CLCS is replacing an existing system where requirements are well defined, the CLCS team will work diligently to challenge and separate real requirements from 20 years of cultural influences, thus minimizing the complexity of design, ensuring that COTS products can be implemented into the CLCS design, and allowing for greater flexibility and creativity in the fulfillment of the “real requirements”.

Involvement of the user community is critical to the success of the CLCS project and therefore this involvement will be part of each phase of each incremental delivery. The user community is responsible for developing, approving, and performing the test plans for the verification, validation, and certification of CLCS. Contributions from software test and integration professionals and the perspective risk management experts (Launch Director, Director of Shuttle Processing, Director of Safety and Mission Assurance, and etc.) will also be included. Figure 11.3-1 illustrates the test and certification philosophy. This process will ensure full compliance to system requirements.

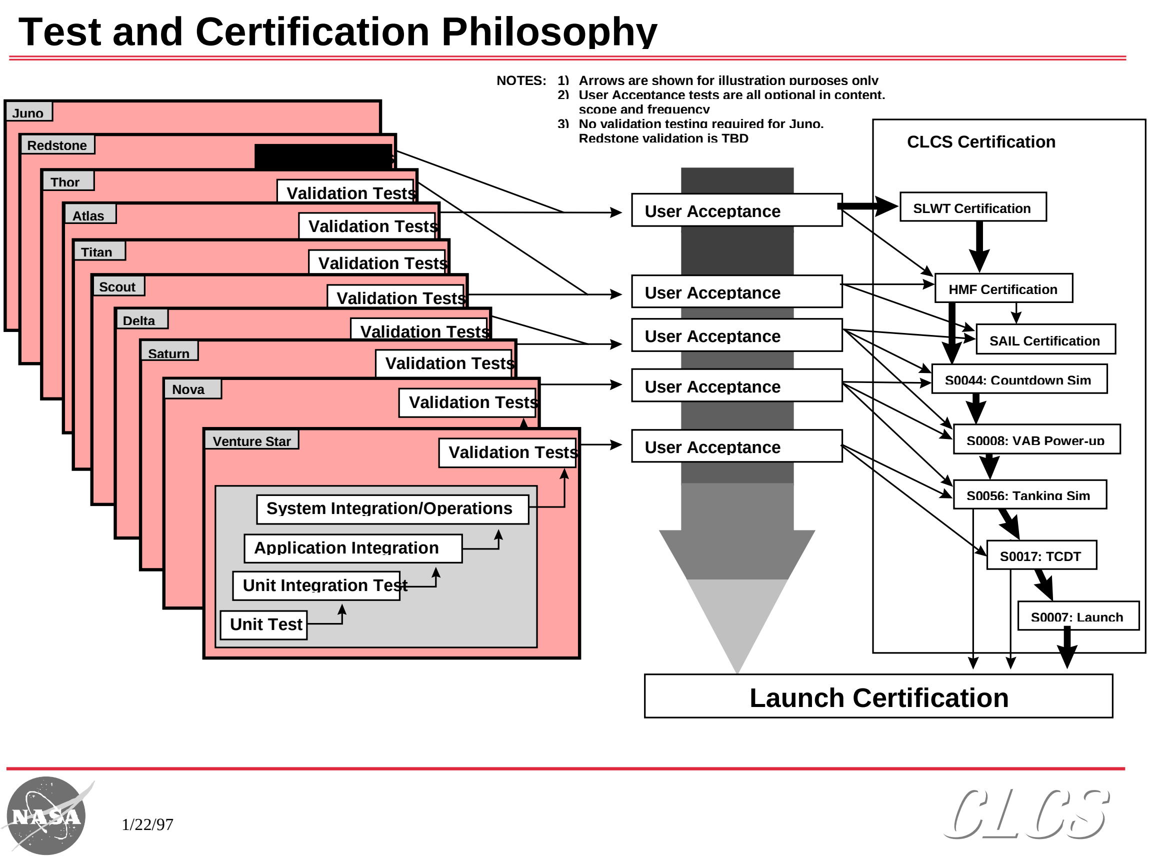

Figure 11.3-1 Test and Certification Philosophy

12.0 PERFORMANCE ASSURANCE

12.1 GENERAL

CLCS will comply with the intent of NHB 5300.4 (1D2), "Safety, Reliability, Maintainability and Quality Provisions for the Space Shuttle Program". “The CLCS Safety and Mission Assurance Plan (84K00055) provides details for performance Assurance activities.”

12.2 RELIABILITY

CLCS Reliability Engineering will follow the intent of NHB 5300.4 (1D2) and tailor the program to sections 1D300 and 1D301. Special emphasis shall be given to fail safe operation and minimizing life cycle costs.

12.3 QUALITY ASSURANCE/ENGINEERING

The CLCS project team will ensure the reliability, quality assurance, configuration management, and independent verification and validation of hardware and software for the CLCS system. The Project activities will comply with the intent of the applicable requirements of NHB 5300.4(1D2)

12.4 PARTS

CLCS will use high reliability parts on this project, including requirements for future replacement parts to assure the integrity of the equipment does not degrade during equipment life. Special considerations shall be given to "critical parts" (i.e. criticality category 1, 1S, 1R & 2).

12.5 SYSTEM HARDWARE

Most all CLCS hardware will be procured as commercial-off-the-shelf. All hardware used in the production/operational environment will be provided by vendors who are ISO 9001 compliant or equal.

12.6 SOFTWARE ASSURANCE

CLCS will meet the intent of software assurance as stated in NASA-STD-2201-93, during the life-cycle of the project for NASA developed and COTS software. Implemented software assurance will reduce the technical and programmatic risk associated with the delivery of software meeting NASA’s technical, schedule, and budgetary needs.

12.7 MAINTAINABILITY

CLCS Maintainability Engineering shall follow the intent of NHB 5300.4 (1D2) and tailor the program to sections 1D400 and 1D401. Special emphasis shall be given to minimizing life cycle costs in concert with logistics and reliability engineering.

13.0 RISK MANAGEMENT PLAN

The risk management process is designed to ensure the early exposure and identification of risk so that favorable mitigation plans can be developed before the identified risk can impact the project. The methodology to continually track progress especially in areas where identified risks are present is essential for effective risk management. This allows for timely execution of mitigation plans, which is the tool for monitoring the selected alternatives in the risk mitigation process. This approach supports sound project management decisions and promotes open discussion among our teammates.

Although tailored and optimized for application to the CLCS project, the CLCS risk management process in itself is not unique. What will determine whether the CLCS Risk Management Plan is effective or not depends on the foresight to effectively chose and use the correct tools in the process. The CLCS project team offers proven ability to manage project risk through both past performance and its current experience managing development projects. Legacy processes and procedures successfully applied on these projects provide a proven baseline for risk management on CLCS.

13.1 INTRODUCTION

The intent of the CLCS Risk Management Plan is to provide a disciplined and documented approach to risk management throughout the project life cycle and to support management decision making in regards to risk assessments (i.e., taking into account cost, schedule, performance, and safety concerns).

13.2 RISK MANAGEMENT APPROACH

13.2.1 Risk Management Philosophy/Overview

For some, risk is what you take, for others, risk is what you avoid. For CLCS to be successful in it’s goals of finding ways to be better, faster and cheaper, risk has to become a partner or resource instead of an enemy. As CLCS challenges the way we have done things for decades, processes that are part of our cultural existence, CLCS will use risk as a tool through effective identification and risk management.

13.2.2 Risk Management Responsibilities

The CLCS Project Manager is ultimately responsible for managing risk for the project. The entire project team will support the Project Manager throughout the risk management process to assure all risks are identified, analyzed, mitigated, and tracked. Additionally, the CLCS PMC (see section 3.1.1) will be a critical resource for the risk management process.

13.2.3 The Risk Management Mindset

Early identification and disclosure of risk and the development of mitigation plans is essential to an effective risk management process. The mature CLCS process will continually track progress against our risk mitigation plans and monitor the project to identify new risks, support sound project management decisions for the overall project for each task, and ensure that there are no surprises throughout the life of the contract.

CLCS risk management is tightly coupled with the product development process. As an integral part of this process, CLCS will promote this mindset on the project through open discussions between all members. These discussions will enable us to identify risks early and to effect changes in our project that will most effectively mitigate these risks. Discussions include informal discussions (product development team activities, memos, emails, and ad-hoc meetings) and formal, scheduled meetings (project status reviews, risk review board meetings, management meetings). Such communications enable project management to remain close to and candid with the team members throughout the life of the project. These interfaces also provide a mechanism to review and use lessons learned in the risk management process by planning for similar risks before they arise, allowing CLCS to remain proactive instead of reactive. Figure 13.2.3-1 illustrates this approach to collective communication.

Figure 13.2.3-1 Risk Management Mindset

13.3 RISK MANAGEMENT METHODOLOGIES, PROCESSES, AND TOOLS

Managing risk effectively involves using the correct tools and processes during risk planning. Figure 13.3-1 illustrates the relationship of the activities associated with successful risk management.

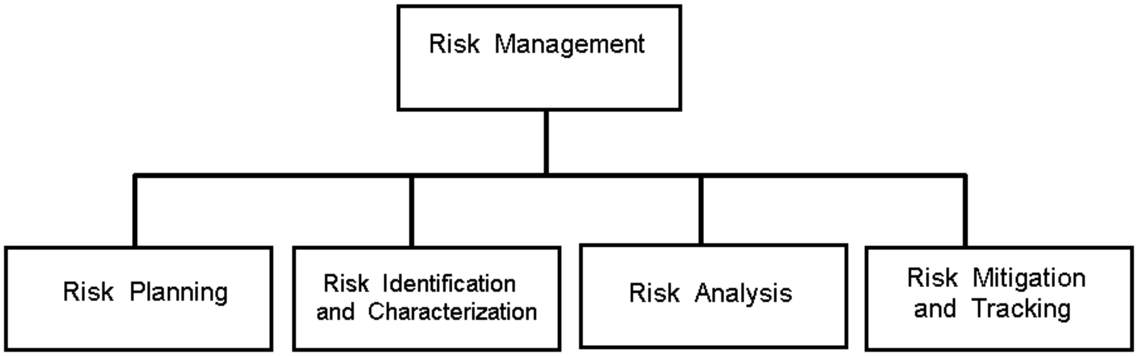

Figure 13.3-1 Structure of Risk Management

13.3.1 Risk Identification and Characterization

CLCS will use a variety of techniques for risk identification and characterization. The thoroughness in which this is accomplished is an important factor to the success of CLCS's risk management program.

13.3.1.1 Expert Interviews

Expert interviews will be a major source of insight and information in the identification and characterization of risk. Being that CLCS is the replacement for the existing Launch Processing System, numerous system experts are available for consultation. As involvement from the user community is critical to the success of the CLCS project, many of these experts are full time members of the CLCS team.

13.3.1.2 Independent Assessments

CLCS will use independent assessments in the identification and characterization of risk in three forms: 1) review of project documentation, 2) evaluation of the WBS for completeness and consistency, and 3) independent cost estimates.

13.3.1.3 Lessons Learned

A thorough review of similar government projects has been conducted in preparation for initiating the CLCS Project. Lessons learned has been and will continue to be one of the more valuable tools for identifying and characterizing risk for CLCS.

13.3.1.4 Risk Templates

Previously developed risk templates (e.g. DoD 4245.7-M) will be evaluated for their potential application in the identification of risk in the CLCS risk management process.

13.3.1.5 FMECAs and Fault Trees

Specialized techniques for safety (and/or hazard) will be reviewed for their potential contributions in the identification and characterization of risk for the CLCS project. Where practical and beneficial, these techniques will be utilized to focus on the system design and to categorize each potential failure mode according to severity.

13.3.2 Risk Analysis

A variety of techniques for risk analysis will be employed in the CLCS risk management process.

13.3.2.1 Decision Analysis

Decision analysis is a technique to help the decision process when dealing with a complex set of uncertainties. CLCS will use this approach when applicable to divide-and-conquer, decomposing complex issues into simpler ones which can then be treated separately. Decision trees will be utilized to illustrate graphical images of the complex problems under going analysis.

13.3.2.2 Probabilistic Network Schedules

Probabilistic network schedules, such as PERT (Program Evaluation and Review Technique) will be a major tool used by CLCS in risk analysis. This tool will allow project management to input minimum, maximum, and most likely duration for each activity which can then be used to determine the probability that the project or a particular task can be completed by a given date. This method of analysis is also valuable in the determination of critical path.

13.3.2.3 Probabilistic Cost and Effectiveness Models

Probabilistic cost and effectiveness models will be used to provide insight into the probabilistic project cost and effectiveness.

13.3.3 Risk Mitigation and Tracking

Typically, four responses to a specific risk are usually available: 1) do nothing and accept the risk, 2) share the risk with a co-participant, 3) take preventative action to avoid or reduce the risk, and 4) plan for contingent action. CLCS will select the appropriate response based on criticality and priorities of the identified risk element.

13.3.3.1 Risk Mitigation by Type

13.3.3.1.1 Technical Risk

Typical technical risk mitigation actions will likely include additional system testing, designing in redundancy, and building a full engineering model.

13.3.3.1.2 Cost Risk

Cost risk mitigation actions will typically include using Commercial-Off-the-Shelf (COTS) hardware and providing sufficient funding during the early phases of the project's life-cycle.

13.3.3.1.3 Schedule/Performance

For CLCS, the mitigation of schedule risks are less systematic and will therefore require more attention. It is often extremely difficult to accurately assess "percentage complete" of a task. This affords the opportunity to gain insight too late in the process, increasing the probability of late deliveries and/or system capability impacts.

13.3.3.2 Risk Mitigation and Tracking Tools

13.3.3.2.1 Watchlists and Milestones

CLCS will use watchlists to track identified risks. These lists will identify triggering events or missed milestones, the related areas of impact, and the risk mitigation strategy.

13.3.3.2.2 Contingency and Descope Planning

CLCS will develop contingency and descope plans in conjunction with specific items identified on the watchlists. These plans will focus on developing work-arounds to be activated upon a triggering event. Mitigation planning may involve beginning the work-around when a triggering event occurs or could also involve early start of parallel efforts which will provide a return only if the triggering event occurs.

13.3.3.2.3 Cost, Schedule, and Technical Performance Tracking

Cost & Schedule Control Systems & Technical Performance Measure Tracking will serve as valuable tools for tracking risk of these key project parameters. The CLCS Performance Measurement Plan will be used to assess cost, schedule, and technical performance beginning with the Redstone delivery. The CLCS Performance Measurement Plan tool is being developed with guidelines which will enable the preparation of a brief but accurate report to provide insight to the overall performance of the project. In general, cost, and schedule performance will be measured and finally cost compared against schedule.

As technical progress provides further insight, Project Plan Reviews will be conducted periodically to assess previously unidentified systems needs against the baseline system requirements.

13.4 SIGNIFICANT IDENTIFIED RISKS

The following is a list of the significant risks currently identified for the CLCS Project. The risks identified in this list and the assessment of each will be evaluated periodically and revised as progress and insight are obtained.

13.4.1 Cost

Cost has been identified as a risk to CLCS. The majority of the hardware acquisitions are planned to be Commercial-off-the-Shelf products which mitigates the cost risk element in regards to hardware.

CLCS is a five year extensive software effort, and software development is the major portion of the 1400 + labor-years effort. Keeping the project on schedule will in itself mitigate cost risks for labor (see Schedule section 13.4.2). Incremental deliveries will add significant insight as to the achievement of “real” milestones and therefore attribute to the mitigation of this risk element. The basis of estimate for CLCS costs have been reviewed by program personnel from JSC and deemed to be adequate. In addition, the Shuttle program has established a reserve for the project of 20%.

13.4.2 Schedule

With an aggressive, success driven, product oriented, five-year schedule, CLCS is in full realization of schedule risk. The CLCS Project has adopted the concept of incremental deliveries to help in the mitigation of technical and schedule risk. By breaking the project up into smaller pieces, the incremental approach provides an accurate insight into overall project status and ensures that the system is delivered.

Having in-depth involvement from the user community throughout the project's life-cycle is another key element to the project's success as this addition to the project team allows for early detection of latent flaws and quick turnaround of system fixes.

The CLCS PMC, chaired by the KSC Center Director, has made assuring the availability of KSC resources its foremost priority. This management commitment has reduced supportability risk in areas where support, facilities, and communications modifications are the predominate threats to the schedule.

The project team is identifying requirements early and obtaining commitments from supporting organizations to mitigate this risk.

There would, of course, be an impact to the schedule and cost of the project should the program change the funding structure already established.

13.4.3 Technical

CLCS is a complex real time command and control environment in support of critical, high energy systems. Technical risk associated with custom software development is mitigated by the availability of expertise on the existing LPS, the use of COTS and industry standards, and the leveraging of technology from MCC and other similar checkout and control systems.

Therefore, CLCS is an application of state-of-the-art technology and is not driving the formulation of new technology. The incremental delivery concept and the dedicated involvement from the user community as discussed in section 13.4.2, also mitigates technical risk.

13.4.4 Capture of System Requirements

There are 12 million lines of code in 3800 applications programs to be re-engineered and totally rewritten in a new language. There will be a tendency on the part of the user community to enhance and expand system requirements. Certain enhancements will be allowed if the benefits are substantial and the work can be accomplished so as to not impact the CLCS overall delivery schedule. A CLCS requirements control board will be established to approve changes to baseline requirements to control and mitigate this risk internally. Programmatically, existing requirements control boards will be utilized to the maximum extent possible. The requirements control board, utilizing its corporate knowledge of these existing application requirements, will approve changes to baseline requirements and thereby control and mitigate this risk.

Being that CLCS is the replacement for the existing Launch Processing System, numerous civil service and contractor system experts are available for consultation in both areas of operations and system requirements. These experts from the operations and user communities are valuable assets to the CLCS team as the team works diligently to challenge and separate real requirements from decades of cultural influences. The user community is responsible for developing, approving, and performing the test plans for the verification, validation, and certification of CLCS. This involvement will provide early user review of the real system and contribute significantly in the mitigation of this risk element.

13.4.5 Funding - Adequacy

The basis of estimate for CLCS costs have been reviewed by program personnel from JSC and deemed to be adequate. An additional 20% reserve has been established by the Shuttle program.

13.4.6 Funding and Project Goals - De-scope Plan

Availability of adequate funding is a risk to any project. There would, of course, be an impact to the schedule and cost of the project should the program change the funding structure already established. CLCS is the replacement for the existing LPS. Requirements for a Launch Processing System that meet safety and mission requirements and standards have evolved from twenty years of operating the existing LPS. De-scoping requirements as a result of potential budget reductions will result in a system that will fail to meet these minimum requirements and therefore will not enable the Program to decommission the existing LPS. CLCS does not plan to incorporate new requirements, but due to capabilities inherent with new technology, CLCS does intend to support new features which are anticipated to provide additional opportunities for achieving cost saving in its operation and use. Therefore, this De-scope Plan does not address reducing or eliminating requirements as specified for a manned space flight program. This plan will define “usable capability” that can benefit the Shuttle Program if CLCS project funding is withdrawn prior to full implementation of the Project’s plans and goals.

If funding were withdrawn following:

First Qtr - FY98 Total CLCS funded project expenditures to date would be approximately $30 million and 90 Civil Service Full Time Equivalent (FTE) Work Years.

LCC-2 Multi-flow - The CLCS transition plan requires the existing Control Room 2 (LCC-2) to be implemented with additional LPS hardware to support multiple non-integrated flows. By this time, the existing Control Room 4 (LCC-4) would have been decommissioned and mid-way through renovation for CLCS.

Although somewhat limited, achieving multi-flow capability in LCC-2 would leave LPS with its current ability to support four orbiters in-flow. Supporting four flow from three control rooms would allow for some O&M cost savings.

Second Qtr - FY98 Total CLCS funded project expenditures to date would be approximately $37 million and 115 Civil Service FTE Work Years.

PCGOAL and Consolidated Data - CLCS would have completed the consolidation of data from numerous satellite systems (e.g. meteorological data, Ground Measurement System (GMS), etc.) that have evolved in an attempt to respond to user requirements that due to lack of capability, could not be implemented on the existing LPS. Refinement and maturing of PCGOAL would have also been accomplished. Some cost savings associated with the O&M of these systems could be realized.

First Qtr - FY99 Total CLCS funded project expenditures to date would be approximately $75 million and 190 Civil Service FTE Work Years.

SDC - CLCS would have completed and implemented the SDC enabling the transition from the CDS to SDC allowing CDS to be decommissioned. This would include the re-host of the Shuttle Ground Operations Simulation (SGOS). Decommissioning CDS would avoid the millennium problem associated with the CDS mainframes and allow for some cost savings associated with the O&M of the existing CDS.

HMF - CLCS would have replaced hardware and re-engineered software to bring the Hypergol Maintenance Facility (HMF) ready for user acceptance. Following user acceptance, the HMF would become operational and the existing HMF LPS set could be decommissioned allowing for some cost savings associated with the O&M of the existing HMF LPS set.

Important Milestone - Reviews will be held in May, 1998 in preparation for procuring hardware for OCR-1, the first major CLCS hardware buy. Being that by the end of first quarter of 1999, OCR-1 will not have progressed to the point of providing any usable capability to the program. If it were known that funding was to be terminated, it would be advisable to avoid this procurement activity. Therefore, early knowledge of project funding termination could save $5 - 7 million.

Second Qtr - FY00 Total CLCS funded project expenditures to date would be approximately $135 million and 340 Civil Service FTE Work Years.

OCR-1 - CLCS would have completed all facility modifications associated with transitioning LPS LCC-4 to CLCS OCR-1 including the procurement and installation of all new enclosures and hardware. OPF system and application software would have been completed and validated enabling CLCS to fully support OPF related processing following an appropriate Operational Readiness Review (ORR). Measurable O&M costs savings associated with the use of OCR-1 could be achieved.

CITE - CLCS would have completed all facility modifications associated with transitioning the LPS Cargo Integrated Test Equipment (CITE) to CLCS CITE including the procurement and installation of all new enclosures and hardware. CITE system and application software would have been completed and validated enabling CLCS to fully support the first CLCS payload flow, leading to the decommissioning of the existing LPS CITE. Measurable O&M costs savings associated with the use of the CLCS CITE could be achieved.

Fourth Qtr - FY00 Total CLCS funded project expenditures to date would be approximately $160 million and 400 Civil Service FTE Work Years.

OCR-1 - Implementation of the first fully operational and launch supportable CLCS control room will have been completed. This would allow one of the two existing launch supportable LPS control rooms to be decommissioned enabling significant O&M cost savings in the operation of OCR-1 to be achieved.

If funding was re-phased:

Re-phasing of the CLCS project by the shift of funding to out years, would extend the duration of the project. In general, the project could be fully implemented if re-phased but would require additional funding, depending on the degree of re-phasing. In addition, re-phasing brings other issues to the surface; i.e. major re-phasing early in the project could impact the development strategy to use the MSC contractor to the extent as currently planned, as this contract will terminate in December, 1999.

In either account, the current LPS suffers from reliability and obsolescence problems which bring the potential for additional rising costs for a system whose O&M costs are already significantly high ($50 million/year). Based on the current launch rate, CLCS has committed to reducing these costs by 50%. Failure to complete the project will significantly affect projected cost savings and still leave obsolescence and reliability issues associated with the current LPS unresolved.

Additionally, LPS has serious expansion limitations, limitations which could preclude the ability for LPS to support Shuttle upgrades. CLCS is a highly flexible system which brings the capability to support these upgrades as well as the ability to support future launch vehicles.

13.4.7 Human Resources - Availability

Key to CLCS success is having the right human resources involved throughout the project's life-cycle. Although civil service and contractors have many experts available to provide valuable insight to the project, the aggressive, success driven CLCS schedule depends on the ability to gain other support in specialty areas. There is also risk that as KSC reduces its work force that there is be an insufficient number of Civil Servants to support CLCS and support KSC's mission. With the CLCS PMC committed to assuring the availability of KSC resources as its foremost priority, this risk is significantly reduced.

Additionally, long term funding provides the job security required to obtain many of the required resources that have been or are to be contracted. There would, of course, be an impact to the schedule and cost of the project should the program change the funding structure already established.

13.4.8 Human Resources - Control / Influence

In addition to Civil Service personnel, the CLCS Project depends on multiple contractors as listed in Section 3.5. CLCS primarily uses SFOC (JSC), MSC (JSC), and ESC (KSC). As these contracts have primary missions and goals other than CLCS, there is risk that CLCS will be unable to be of sufficient influence to positively affect contractor performance. Specific completion form deliverables have been defined and assigned to each contractor to mitigated this risk. A procedure has been established to input performance criteria specific to each contractor as well as evaluation of the contractor accordingly.

13.4.9 Impact to Manifest/Transition

In parallel with the attempt to minimize costs for the project, CLCS intends to reuse the existing LPS facilities in the implementation of CLCS. Although this approach offers the benefit of significant cost savings, the down side is the potential for impact to the on-going Shuttle processing and launch manifest. The CLCS transition plan depends on the cooperation of the processing and launch team for its success. As vital members of the processing and launch team are actively involved in CLCS's life-cycle, the CLCS team is very optimistic that transition from LPS to CLCS, while reusing the existing LPS facilities, can effectively be accomplished with minimal or no impact. Risk from technical issues associated with the transition from LPS will be mitigated by thorough test, validation, and certification plans. Users and experts will be involved in the development and implementation of these plans. Individuals skilled in the management of risk related to launch system will be involved in the approval of the overall process.

13.4.10 Commitments

The project has committed to achieving successful completion within five years ending in FY2001. The critical path for CLCS is the development , test, and certification of application software. Key milestones for application software development are part of an integrated package which composes each incremental delivery. Included in that package are additional milestones for facility modifications and transition.

The project has also committed to reducing O&M costs by 50% by increasing console MTBF from 70 hours to 10,000 hours, by decreasing the amount of hardware from 8 control rooms to 6, by using standard COTS software and reducing custom software from 12 million lines of code to 3.3 million, and by designing for system components to be returned to vendor while maintaining 100% daily support capability.

Additional commitments are identified in the Program Commitment Agreement (84K0007). CLCS will establish measurements to monitor the progress towards achieving the commitments described herein. Project management, as well as the CLCS PMC, will closely monitor this risk element.

14.0 ENVIRONMENTAL IMPACT

CLCS has no environmental impacts.

15.0 SAFETY

The CLCS project team will maintain a safety activity to protect the life, health, and well being of Government and Contractor employees, as well as property and equipment. CLCS project activities will comply with applicable provisions of KHB 1710.2C, "Kennedy Space Center Safety Practices Handbook." Software safety shall be an integral part of the overall CLCS system and software development efforts. It is the objective of the software safety effort to ensure that safety is considered throughout the software life cycle. CLCS software safety activities shall comply with the intent of NSS 1740.13, "NASA Software Safety Standard."

16.0 SECURITY

CLCS will follow the intent of the existing LPS Security Plan K-TE-LPS-01. Additionally, as the project develops, a Security representative will be identified as a team member. They will be responsible for coordination and integrating CLCS security planning and risk management activities.

CLCS will comply with the automated information security requirements of NASA and the Space Shuttle Program. Security will be integrated into all phases of the project life-cycle process to ensure functional requirements and technical specifications are addressed.

17.0 CLCS ACRONYMS

	- A -
ACA	ADAS Command Application
ADAS	Advanced Data Acquisition System
AERO	Automated Electrical Retest Operations
ALS	Automated Logging System
AMRS	Automated Material Request System
ANSI	American National Standards Institute
AOS	Analog Overflow Signed
API	Application Program Interface
APU	Auxiliary Power Unit
ASM	Analog Serial Measurement
ATM	Asynchronous Transfer Mode
AWPS	Automated WAD Processing System
	- B -
B/U	Backup
BCD	Binary Coded Decimal
BFL	Block Funnel Logged
BIN	Business and Information Network
BTU	Bus Terminal Unit
	- C -
C&T	Communications and Tracking
CADS	Command and Data Simulator
CCC	Complex Control Center
CCMS	Checkout, Control, and Monitor System
CCP	Command and Control Processor
CCS	Complex Control Set
CDBFR	Common Data Buffer
CDT	Countdown Time
CEA	Common Equipment Area
CEU	Calibrated Engineering Units
CI	Configuration Item
CIE	Communications Interface Equipment
CITE	Cargo Integrated Test Equipment (Set)
CLCS	Checkout and Launch Control System
CM	Configuration Management
COLA	Collision Avoidance

COTS	Commercial Off the Shelf
CPDS	Computer Program Development Specifications
CPU	Central Processor Unit
CRMP	Command and Real-Time Monitor Position
CRT	Cathode Ray Tube
CS	Consolidated Systems
CSC	Computer Software Component
CSCI	Computer Software Configuration Item
CWLIS	Catenary Wire Lightning Instrumentation System
	- D -
DAP	Data analysis and Presentation
D/L	Downlink
DBSAFE	Data Bank Shuttle Automated Function Executive
DCN	Display and Control Network
DD	Data Dictionary
DDP	Data Distribution Processor
DFRC	Dryden Flight Research Center (Set)
DIO	Direct Input/Output
DLES	DPS LCC Expert System
DPS	Data Processing System
DSR	Display Synchronous Rate
	- E -
EDAMS	Engineering Data Access Management System
EDL	Engineering Development Laboratory
EIU	Engine Interface Unit
EU	Engineering Units
	- F -
FCAP	Facility Condition Assessment Program
FD	Function Designator
FDDI	Fiber Distributed Data Interface
FDID	Function Designator ID
FEP	Front End Processor
FOTE	Fiber Optic Terminal Equipment
FTP	File Transfer Protocol
FZ	Flow Zone
	- G -
GCP	Gateway Control Processor
GDB	Ground Data Bus
GMS	Ground Measurement System
GMT	Greenwich Mean Time
GOAL	Ground Operations Aerospace Language
GPC	General Purpose Computer
GSE	Ground Support Equipment
GUI	Graphical User Interface
G/W	Gateway

- H -

HAZGAS	Hazardous Gas
HCI	Human Computer Interface
HGDS	Hazardous Gas Detection System
HIM	Hardware Interface Module
HMF	Hypergol Maintenance Facility (Set)
HOSC	Huntsville Operations Support Center
HUMS	Hydrogen Umbilical Mass Spectrometer
HWCI	Hardware Configuration Item
	- I -
IAPU	Improved Auxiliary Power Unit
IDE	Integrated Development Environment
IEEE	Institute of Electrical and Electronic Engineers
I/O	Input/Output
IP	Internet Protocol
IPR	Interim Problem Report
IRIG-B	Inter-Range Instrumentation Group
ISO	International Standards Organization
IVT	Interface Verification Testing
IWCS	Integrated Work Control System
	- J -
JSC	Johnson Space Center
	- K -
KATE	Knowledge-Based Autonomous Test Engineer
KATS	Kennedy Avionics Test Set
Kb	Kilo-bit
Kbs	Kilo-bits per second
KB	Kilo-Byte
KBS	Kilo-Bytes Second
KEDS	Kennedy Electric Drawing System
KSC	Kennedy Space Center
KSDN	Kennedy Switched Data Network
	- L -
LACD	Local Acquisition, Command, and Display Subsystem
LAN	Local Area Network
LATMOS	Lightning and Transients Monitoring System
LDBM	Launch Data Bus Monitor
LCC	Launch Control Center
LCC	Launch Commit Criteria
LDB	Launch Data Bus
LO_2	Liquid Oxygen
LOC	Lines of Code
LON	LPS Operational Network
LH_2	Liquid Hydrogen
LPS	Launch Processing System

LRU	Line Replaceable Unit
LS	Launch Sequence
LSDN	LPS Software Development Network
LIVIS	Lightning Induced Voltage Instrumentation System
	- M -
Mb	Megabit
Mbs	Megabits per second
MB	Megabyte
MBs	Megabytes Second
MCP	Model Control Procedures
MDM	Multiplexer/Demultiplexer
ME	Main Engine
MER	Mission Evaluation Room
MET	Mission Elapsed Time
MFR	Multi-function Room
MFSC	Marshall Space Flight Center
MILA	Merritt Island Launch Area
MM	Mass Memory
MMU	Mass Memory Unit
MOIR	Mission Operations Integration Room
MPT	Mini-Peripheral Test (Set)
MSec	Millisecond
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
MTU	Mission Timing Unit
	- N -
NASA	National Aeronautics and Space Administration
NFS	Network File System
NSP	Network Signal Processor
	- O -
O&M	Operations and Maintenance
OCF	Orbiter Computational Facilities
OCR	Operations Control Room
OFI	Operational Flight Instrumentation
OIS	Operational Intercom System, also OI Standby (FEP)
OLDB	On Line Data Base
OLSA	Orbiter LPS Signal Adapter
OMI	Operations and Maintenance Instruction
OMRSD	Operations and Maintenance Requirements and Specification Documentation
OMS	Orbital Maneuvering System
OPF	Orbiter Processing Facility
ORT	Operational Readiness Test
OTV	Operational Television
OV	Orbiter Vehicle

- P -

PAMS	Portable Aft Mass Spectrometer
PCC	Processing Control Center
PCL	Prerequisite Control Logic
PCM	Pulse Coded Modulation
PCMMU	Pulse Coded Modulation Master Unit
pF	Pico-Farad
PFP	Programmable Function Panel
PLC	Programmable Logic Controller
PMS	Permanent Measurements System
POCC	Payload Operations Control Center
POST	Power On Self Test
ppm	Parts Per Million
PRACA	Problem Reporting and Corrective Action
PSCNI	Program Support Communications Network Internet
	- Q -
	- R -
RADS	Remote Acquisition and Display Subsystem
RAID	Redundant Array of Inexpensive Disks
RCS	Reaction Control System
RCVS	Remote Controlled Video Switch??
RNET	Reconfiguration Network
RON	Restricted Operational Network
RSYS	Responsible System
RTCN	Real-Time Critical Network
RTPS	Real-Time Processing System
RTU	Remote Terminal Units
	- S -
SACS	Systems Software Avionics Command Support
SAIL	Shuttle Avionics Integration Lab (Set)
SBC	Single Board Computer
SCA	Sequence Control Assembly
SCAN	Shuttle Configuration Analysis Network
SCID	System Configuration Identifier
SCSI	Small Computer System Interface
SCT	System Configuration Table
SDC	Shuttle Data Center
SDE	Satellite Development Environment
SDS	Shuttle Data Stream
SDT	Shuttle Data Tape
SECAS	Shuttle Engineering Computer Application System
SGOS	Shuttle Ground Operations Simulator
SIM	Simulation System
SIMS	Still Image Management System
SL	Space Lab

SLOC	Source Lines of Code
SL-GMS	Sherrill-Lubinski-Graphical Modeling System
SLP	SSME Load Program
SLS	System Level Specification
SLWT	Super Light Weight Tank
SODN	Shuttle Operations Data Network
SONET	Synchronous Optical Network
SPDMS	Shuttle Processing Data Management System
SPF	Software Production Facility
SRB	Solid Rocket Booster
SSC	Stennis Space Center
SSME	Space Shuttle Main Engine
SSPF	Space Station Processing Facility
SSR	System Synchronous Rate
STM	Synchronous Transfer Mode
	- T -
TAB	TACAN Bearing (SDT Type)
TACAN	Tactical Air Navigation
TBD	To Be Defined
TCID	Test Control Identifier
TCMS	Test, Control and Monitor System
TCP	Transmission Control Protocol
TCS	Test Control Supervisor
TCS-1	Test Control Supervisor - Single Command
TCS-S	Test Control Supervisor - Sequence
TDM	Time Division Multiplexing
TEI	Test End Item
THDS	Time Homogenous Data Set
	- U -
UOPS	Utility Outage Processing System
USCA	Universal Signal Conditioning Amplifier
UTC	Universal Time Coordinated
	- V -
V&DA	Video and Data Assembly
VAB	Vehicle Assembly Building
VHMS	Vehicle Health Management System
VP	Vehicle Processing (Set)
VPF	Vertical Processing Facility
VSI	Video Simulation Interface
VTP	VME Telemetry Processor
	- W -
WAN	Wide Area Network
W/S	Workstation
	- X - Z -

END